INTEGRATED EDITION OF THE PETROLEUM ENGINEER

the Petroleum Engineer

FOR MANAGEMENT

AUGUST 1960

CONTENTS: 2 AD INDEX: 4

ONE DOLLAR PER COPY

What Makes a Good Executive?

Humble Division president discusses basic leadership qualities — Page E-4

ENI Uses Management Engineering

New function streamlines procedures for Italian company — Page E-7

Watch Your Finances

To be a manager you must learn to manage your own money — Page E-13

What Is the Role of the Independent?

Producers drill most wildcats, refiners stress flexibility — Page A-20b

How to Measure Profitability

Five evaluation methods to predict return on plant investment — Page C-14

Argentina Builds Its Biggest Line

Mobile towns, temporary airstrips used in $200-million project — Page D-14

Water Filtered Twice Pays Off

Individual injection wells treated separately in flooding — Page B-19

MORE EFFECTIVE ACIDIZING WITH THE EXCLUSIVE NEW "ACID GUIDE" BEGINS HERE

This is a Dowell field laboratory. From more than 40 such installations strategically located throughout the oil producing areas, Dowell can provide a new method for engineering more effective acid treatments. This new method is called the "Acid Guide."* When the "Acid Guide" is used as a basis for planning a treatment, the Dowell engineer first tests core samples or cuttings for solubility and reaction rate. Using this data, he can determine the optimum injection rate, amount of acid and acid formula. This new, greatly improved method for planning and predicting the results of oil well acidizing treatments is available *only* from Dowell . . . and at no extra cost . . . another example that you get more for your money when you *dial Dowell.* Dowell, Tulsa 1, Oklahoma.

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Oil Gets Planked

The three-ring political circus is over. The arenas in Los Angeles and Chicago are empty and quiet. Despite much inner-party strife by both the Democrats and Republicans, most differences were resolved. Both conventions adjourned on a note of confidence by emphasizing a solid front and a victory in November. That is as it should be. That is the American way, and not one of us would swap it for any other system in the world.

Our interest should not end with the convention, however. That's just window dressing and the part of the show that we have come to expect. Whether we realize it or not, the politicians are running the country. Consequently, we need to and must understand how the political process functions. We need to understand how it works at the local, as well as the national, level. We need to and must understand the issues. No longer can we afford to sit on the sidelines. Only through active participation can we have a voice in what affects our business, our community, and our country.

Have you read the platforms adopted by the recent conventions? We urge you to study carefully the plank both parties endorsed regarding a national fuels policy. You are in the oil and gas industry. Fuel is your business. Your vote and influence for what is best for the solvency of your country and your industry in November is vitally important.

In September, The Petroleum Engineer family of publications will present a basic course in politics in one easy-to-read article. The author, Joseph J. Eley, points out, "If you don't choose your candidates, someone else does it for you." Mr. Eley, president of Public Affairs Counselors, Inc., New York, not only tells us why political understanding and political skill is so necessary for all of us today, but also shows us how we can acquire it and put it to work in our business and everyday life.

On page A-6 of this issue in our Course of Oil feature, "Where Freedom Ends," Ernestine Adams sketches in a few words a chilling picture of what could happen in the United States if our industry is controlled in Washington. Most of our companies have set up political programs of information. Now's the time to give them a workout.

Joe B. Hoover

Publisher

THE PETROLEUM Engineer

FOR MANAGEMENT

NUMBER 9 • VOLUME XXXII • AUGUST, 1960

What is the Role of the Independent? **A-20b**
The producer drills 80% of the wildcats ... the refiner depends on flexibility.

E SECTION FOLLOWS A

What Makes a Good Executive? **E-4**
An interview with Ray H. Horton, president, Humble Division.

Management Engineering Scores with ENI **E-7**
Italian company uses Tecnica Direzionale to streamline procedures and to develop managers. — *Wilson J. Bentley*

Watch Your Finances **E-13**
"How to be a manager" includes knowing how to manage your money. — *R. Lee Owens*

Check Those References **E-18**
Failure to check references adequately results in a 50% chance of hiring the wrong person.

Got a Minute **E-18**
What do you do with the time you save?

Publisher's Page A-1
Highlights and Footnotes A-3
Advertisers' Index A-4
Course of Oil A-6
Where Freedom Ends
Petroleum Profile A-8
William L. Graham
Conference Table A-10
Meetings E-20
Laugh with Barney E-21
Management Personals E-24
Of Things to Come in Oil B-3
What's Doing in Drilling B-80
Running Tour B-85
Exploration Activities B-88
Drilling and Producing Equipment B-92
Drilling and Producing Literature B-99
Suppliers' Parade B-101
Process Notebook C-19
Petro/Chem Literature C-49
Petro/Chem Equipment C-52
Shaping the Future D-3
Pipeline Projects D-44
With the Pipeline Contractors D-49
Pipeline Personals D-52
Pipeline Parade D-54
Pipeline Equipment D-55
Pipeline Literature D-58

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DRILLING AND PRODUCING

Secondary Water Filtration Pays Off B-19
— *E. J. Simmons and Luther F. Ellison*
Opportunities in Southwest Texas B-23
Sonic Log Evaluates Morrow Sand in Western Oklahoma B-29
— *Frank S. Millard*
Modern Well Completions, Part 8a
Formation Testing Fundamentals B-36
— *Cecil R. Richardson*
India Invites Oil Capital B-59
— *Edward V. Corps*
PESA Elects New Officers B-68
Simplified Log Interpretation, Part 3 ..... B-70
— *Terry Walker*

PETRO/CHEM ENGINEER

Special Issue Editor, Dr. John Happel, P.E. C-8
Selection of Plant Capacity C-10
Robert D. Newton
How to Measure Project Profitability C-14
— *J. C. Martin*
Consider These Factors Affecting Plant Costs C-23
— *Ralph W. Clark*
Obtain Speed and Accuracy in Preliminary Appraisals C-27
— *E. A. Schraishuhn and John Kellett*
How to Evaluate Plant Design Problems C-34
— *John Happel and W. H. Kapfer*
The Right COS Can Reduce Pumping Costs C-40
— *T. J. Sniffen*
Filling the Estimator's Tool Box C-42
— *William I. McKay*
Mathematics Workshop, Algebra, Part 3 ..... C-47
— *J. M. Marchello*

PIPELINE ENGINEER

Argentine Project ... Unique Pipeline Construction D-14
— *Frank H. Love*
Laurel's Concept of Control Equipment Use Proves Sound D-26
— *Marlan G. Jordan*
Gas "Bubble" Storage D-29
— *Dean Hale*
Control Computing, Part 1 ..... D-31
— *Geoffrey Post*
Silencing Two-Cycle Turbocharged Engines D-36
— *Edgar S. Stoddard*
PIPELINE FUNDAMENTALS
Underground Corrosion and Methods of Control, Conclusion D-39
— *O. C. Mudd*

Global Notebook

SPANISH OIL INDUSTRY HITS THE HIGH ROAD. From new laws and concessions to beginning of a petrochemical industry — operations in Spain, Spanish Sahara and Spanish Guinea gather strength. In the next Global Notebook you'll get precise and comprehensive information about interesting developments in these areas.

Would you believe that 60 important wells have been drilled on the mainland? You'll be surprised at other facts revealed in the excellent review by an authority, Eduardo Recasens, assistant manager of the technical division of Compania Espanola de Petroleos S. A.

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Highlights and footnotes

Canada vs FPC. Alberta Premier Manning objects to Federal Power Commission price conditions on Canadian gas exported to U. S. He said the Alberta companies would be indirectly regulated by a U. S. agency. Note to Premier Manning: U. S. overproduction of regulations has forced exports.

Want 18-Cent Hike. Union negotiators on nearly 700 contracts (of oil companies and the Oil, Chemical and Atomic Workers) will ask for 18¢ an hour wage increase if the policy committee's goal is accepted. Current wages in oil industry are $2.97/hr. Last increase was 5% in January, 1959. Dwindling profit margins may find companies harder to deal with this year.

Cut-Rate Crude. Russia offered India about 25% off (plus freight) of free world crude prices and agreed to accept rupees in payment. Stanvac cut its prices to meet the Soviet competition. Other foreign companies with refineries in India — Shell and Caltex -- will probably follow Stanvac.

Plymouth to Houston. A new headquarters for exploration, producing, refining, and marketing operations has been set up at Houston, Texas, by Plymouth Oil Company, according to Walter Hallanan, president. This will consolidate many functions and eliminate duplication of services at various locations. Executive offices will remain in Benedum-Trees Building, Pittsburgh.

Want More Asphalt. Four companies petitioned the government to take import controls off crude oil used to make asphalt. Atlantic, Cities Service, Standard Indiana and Standard California said exemptions for imports into area east of Rocky Mountains would not cause increased imports. Proposed regulations for the innovation are complicated but industry now inured to that.

It's Halliburton. A name long familiar in oil fields around the world — Halliburton Oil Well Cementing Company — has been changed to Halliburton Company. More than 99.9% of the voting Halliburton stockholders gave formal approval to the new name. The change was made because Halliburton provides a number of oil field services and products in addition to cementing and has entered other industries to market several products and services that were originally developed for oil field use.

Act for Coal Research. Interior Secretary Seaton began in July to establish an Office of Coal Research. Aim will be to increase utilization and output of coal. This new bureau will probably not affect coal's demand for a national fuels policy.

Products Prices Rise. Wholesale and retail gasoline prices are following usual summer trend of inching upward. Increases are generally 1¢ a gallon. Sun Oil reported its 1¢ rise the same as drop last year. Improved demand has sent fuel oil in Mid-Continent up ½¢ a gallon.

Early Months Slow. Little change appeared in U. S. domestic oil affairs in the first four months of 1960. Crude oil output was down 1% from 1959; including all liquids, up 2%, reports Bureau of Mines. Imports — crude and products — decreased 2%. Domestic demand edged up 2%. Not very exciting until you remember this demand is 10,-255,000 b/d!

Refining Balloons. Oil products are over-swelling again as demand increases. May showed improvement over last year and remainder of '60 looks promising. Even if consumption rises heavy product inventories can depress prices.

8-Day Quota Set. Texas R. R. Commission continued the 8-day production rate for August. Independent producers argued for the low proration with most majors asking for 9 or 10 days.

Depletion Decision. The Supreme Court ruled that the depletion allowance applies only to raw materials — not to income from finished products. Some integrated mining companies applied depletion to processed minerals.

It Hurts! $8.5 billion in taxes in one year . . . that's probably the biggest reason the oil business is sluggish. It's more than double total earnings. No other industry was so brutally taxed in 1959.

ADVERTISERS' INDEX

— A —

ACF Industries, Incorporated — W-K-M Division E-22, E-23
The Air Preheater Corporation D-46
Ajax Iron Works B-15
Allied Chemical Corp., Solvay Process Division C-61
Allis-Chalmers D-4, D-5
American Petroleum Institute A-18
Aquaness Department, Atlas Powder Company B-4
Axelson Manufacturing Company, Division of U. S. Industries, Inc. B-17

— B —

The Babcock & Wilcox Company, Tubular Products Division A-20f
Baker Oil Tools, Inc. B-18, B-38, B-39
Baroid Division, National Lead Co. B-96, B-97
Betz Laboratories, Inc. C-54, C-55
Black-Sivalls & Bryson, Inc. A-16, A-17
Brakesol, Inc. B-79
B&W, Inc. B-98
Byron Jackson Tools, Inc., A Subsidiary of Borg-Warner Corporation B-37

— C —

Cabot Shops, Inc. B-1
Camco, Inc. B-14
Cameron Iron Works B-72, D-40, D-41
Caterpillar Tractor Company A-15
A. B. Chance Co. D-50
Clark Bros. Co. D-8
Classified Advertising E-27
The Cleveland Trencher Co. D-6
Collins Radio Company, Texas Division Sales A-20d
Continental-Emsco Company, a Division of The Youngstown Sheet and Tube Company B-5
The Colorado Fuel and Iron Corporation B-66
Core Laboratories, Inc. B-89
Crane Co., Industrial Products Group C-58, C-59
Crose-Perrault Equipment Corp. D-53
The Crossett Company, Chemical Division B-85

— D —

Degussa-Hanau C-61
Dowell ..... Inside Front Cover, B-56, B-57
E. I. Du Pont de Nemours & Co., Inc. C-45, C-46
The Duriron Company, Inc. D-48

— E —

Ethyl Corporation C-4, C-5

— F —

Fleetline Co. D-58
The Foxboro Company D-2

— G —

Garrett Oil Tools, Division of U. S. Industries, Inc. D-57
General American Transportation Corporation, Plate & Welding Division E-12
Geolograph Oil Field Service Co. B-100
Grant Oil Tool Company B-93
Gray Tool Company B-84
The Guiberson Corporation B-47
Gulf Oil Corporation E-2, E-3
Gulf States Asphalt Company, Inc. D-11

— H —

Hagan Chemicals & Controls, Inc. B-75
Halliburton Company B-12, B-13, B-43, B-81, Back Cover
The Happy Company D-45
Harbison-Fischer Mfg. Co. B-87
Hardy-Griffin Engineering Corporation, A Division of Atlas Pipe, Inc. B-100
The Harshaw Chemical Co. C-1
Hercules Powder Company C-52
Houdry Process Corporation C-39
Houston Rent-A-Car E-26
Hotel Jefferson E-27
Hydril Company B-35

— I —

International Harvester Co., Construction Equipment Division E-15
The International Nickel Company, Inc. B-94

— J —

Jensen Bros. Mfg. Co. B-78
Johnston Testers, Inc. B-10
Jones & Laughlin Steel Corporation D-12, D-13

— K —

The M. W. Kellogg Company, A Subsidiary of Pullman Incorporated A-20e
KLM Royal Dutch Airlines A-20
Koppers Company, Inc., Tar Products Division D-9

— L —

Lane-Wells Company ..... Inside Back Cover
Layne & Bowler, Inc. E-19
Liberty Manufacturing Company of Texas B-63
J. E. Lonergan Co. E-20
Lone Star Steel Company A-7
The Lufkin Rule Company A-11

— M —

Mack Trucks, Inc. B-71
Magnet Cove Barium Corporation B-76
The Majestic Hotel E-27
John N. Martin, Manufacturer B-101
Martin-Decker Corporation B-79, B-92
The Mercoid Corporation C-33
The Mayo Hotel E-27
Mid-Continent Supply Co. B-73
Mission Manufacturing Co. B-8
Montello, Inc. B-82
Motorola Communications & Electronics, Inc. D-7

— Mc —

McCord Corporation D-56
McCullough Tool Company B-7

— N —

The National Supply Company B-51, B-52, B-53, B-54
National Tank Company E-28
National Tube Division of United States Steel C-50, C-51
Nordberg Mfg. Co. D-10
Nordstrom Valve Division, Rockwell Manufacturing Company E-10, E-11
W. C. Norris, Manufacturer, Division of Dover Corporation B-6, B-86, B-102

— O —

Oil Center Tool Co. B-69
Oil Metering and Processing Equipment Corporation B-98
Oil Well Supply Division of United States Steel A-9
Otis Engineering Corporation B-9, B-48, B-49

— P —

Parsons Company, A Division of Koehring Co. D-54
Payne Manufacturing Co. B-101
Petroleum Electric Power Association A-14
Pipe Linings, Division of American Pipe and Construction Co. A-20a
Pipeline Cleaners Co. D-58
Pipeline Inspection Co., Inc. D-55
Polyken Products, Division of The Kendall Co. D-1
The Wm. Powell Company C-57
Procon Incorporated A-20g

— R —

Radiator Specialty Co. C-61
The Rector Well Equipment Company B-41
Reed Roller Bit Company B-64, B-65
Refinery Supply Co., A Subsidiary of Central Scientific Co. E-24, E-25, E-26
Republic National Bank of Dallas A-5
Rockford Clutch Division, Borg-Warner B-95

— S —

Schlumberger Well Surveying Corporation B-83
Security Engineering Division B-45
Shaffer Tool Works B-90, B-91
Sievers, Inc. B-102
M. B. Skinner Co. C-56, D-56
Skinner Brothers Company A-19
Standard Oil Company (N. J.) E-17
The Stearns-Roger Mfg. Co. C-3
Steel Forgings, Inc. D-52
Stephens Engineering B-102
Stratford Engineering Corporation C-60

— T —

Teletype Corporation, Subsidiary of Western Electric Company, Inc. D-47
Thompson Tool Co. B-99
Trinity Portland Cement Division, General Portland Cement Company B-11

— U —

Unit Crane & Shovel Corp. E-1
United States Steel Stainless Steel C-6, C-7
Universal Atlas Cement Company C-26
Universal Oil Products A-20h

— V —

Valley Electric Company E-21
Henry Vogt Machine Co. C-2

— W —

Washington Iron Works, Inc. C-56
Waukesha Motor Company B-61
Welex, Inc. B-2
Western Supply Company C-62
Frank Wheatley Pumps & Valves E-18
The Wheland Company B-16
Widder Sales Corp. D-51
T. D. Williamson, Inc. D-50
Wilson Supply Company B-77
W-K-M Division of ACF Industries, Incorporated E-22, E-23

THIS INDEX IS PROVIDED AS AN ADDITIONAL SERVICE FOR OUR READERS — THE PUBLISHER ASSUMES NO RESPONSIBILITY FOR ERRORS OR OMISSIONS

THE RACE BELONGS TO THE SWIFT

Events can move like greased lightning in the oil and gas industry . . . and the bank giving maximum service is the bank with the experience, knowledge, manpower and resources to move with them. When an oil and gas man brings his financing requirements to Republic, time-and-money consuming delays are cut to the bone. Republic's petroleum engineers are in the field, making professional on-the spot evaluations . . . therefore, action is swift!

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Course of oil

Where Freedom Ends

PICTURE THE PETROLEUM industry with a cut in the percentage depletion allowance and drilling permits issued only in Washington. Then picture the power of the head of a Federal bureau who can tell you — and everyone else — what energy you can use and whether you can have any.

When these events shall come, and they are all promised, freedom ends.

Because we are the most important single element in our economy, the social philosophers have only to take us over to knock down the kingpin. An administration that allocates oil and gas has the nation firmly in its hands.

When William Connole, ex-Federal Power Commissioner, spoke before TIPRO two years ago, he said the gas industry should be proud that it had become important enough to be regulated by the Federal Government.

From that viewpoint the petroleum industry should be more proud that the platform of the Democrat Party gave it special planks. The extreme left-wingers who wrote the platform put a nix on the depletion tax provision and promised to establish a national fuels policy (the coal industry's answer to competition).

Are you tired of being proud of this kind of distinction which leads to extinction?

You can, with cause, be cynical about party platforms. One commentator said the plank against the depletion allowance was included in a Kennedy-dominated platform committee to embarrass Johnson of Texas. But it was overwhelmingly approved and labor leaders, the ADA, and other leftists are not going to forget it as business appeared to forget the 1952 Republican promises of lower budgets.

It isn't a party matter, although Vice President Nixon said he was for percentage depletion for oil and gas. There is Senator Williams (Rep-Del) who works hard to cut the basic percentage allowance that protects producers' capital. His bill lures saner economic heads — he combines a reduction to 22% (from 27½%) depletion with a 60% maximum on income tax.

Martin Row, Sun Oil, points out in *The Landman* that some of the FPC staff are laying the ground-work to contend FPC has jurisdiction over oil as well as gas because, they say, oil is merely a by-product of gas. Are you surprised at this switch?

Row also said that two producers had already fallen in with the suggestion that they get permits from the FPC before drilling gas wells. When everyone goes to Washington before he drills a well, how many will be drilled?

THE KEYSTONE petroleum industry upholds the arch of economic freedom and if we go down, all business falls into political control. Nikita will not have to wait for our grandchildren to be Communists. We can have a third item to be proud of — we'll be ahead of his predictions.

We owe a renewed struggle not only to ourselves but to our customers and, most of all, to our nation. Can our protest now be strong enough? Do we have effective political techniques to keep our industry and our country free? Only you can answer that.

—Ernestine Adams

Congrats and $25 to Robert W. GUTEKUNST, Esso Research and Engineering Company • Post Office Box 8, Linden, New Jersey

Joe Roughneck, backbone of the oil and gas industry, sees many a truck of tough Lone Star pipe roll onto well locations from the bayous of the Gulf Coast to the plains of the Williston basin. He knows delivery will be *on time* because Lone Star pipe is stockpiled . . . in quantity . . . in the heart of the oil country.

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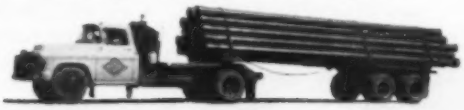

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petroleum profile

"Pick business associates smarter than you are."

William L. Graham manufactured his own opportunities, packed good fortune on his back; and the kindness of fate has been equalled by his joyous labors to make it so.

"Bill," his friends will tell you, "would be a success in any time or place you put him."

In Wichita, Kansas, where he is regarded as a sort of unpredictable but generally beneficial tornado, Bill is known as a partner in Graham-Michaelis Drilling Company and president of Private Enterprise, Inc.

Graham-Michaelis is a seven-rig outfit drilling 60 deep wells a year in Kansas, Oklahoma and Texas Panhandle down where the Anadarko Basin begins to get rugged. It is captained by W. A. Michaelis, Jr., whose administration is such as to make the firm highly successful and therefore the least of Graham's worries.

For Bill, like a 20th century Atlas, has the world on his back —

In his mail box every day are 100 letters from virtually every country in the world; his phone rings all day with

calls from every continent; and a constant stream of visitors pours into the Graham Building in downtown Wichita.

Everyone wants to see Bill, and everyone gets to see Bill.

As president of Private Enterprise, Inc., supervising investments and coordinating ventures in 15 countries, Bill, by any popularity index, is the best known oil man in the world.

His world-wide venture, a combination of shrewd business and a politico-economic missionary campaign, was founded on the theory that the best way to beat Communism is to make capitalists out of Mr. Khrushchev's best prospects.

The idea came to Bill in 1957, when, after buying $15,000-worth of round-the-world plane tickets for his wife and six children, he landed with a bang in Bangkok, Thailand. Interviewing bright young nationals at random, he found all resigned to a life in the service of others. No money was cheaply available to those who wanted to establish ventures of their own.

To Bill, whose career had been launched on a $200 loan, this was appalling. His response was characteristically dramatic. He announced that he would lend $5000 each to the five young men who presented him with the best ideas for business ventures. Bangkok nearly mobbed him.

He repeated the offer successively in Pakistan, India, Indonesia, Turkey, Lebanon, Greece and London as the international press followed in his hectic wake. By the time he reached home, he found himself with eight bags of mail and an idea too big for any one person.

Now the idea is streamlined and capitalized at a little over a million dollars, half of which has been plowed into ventures throughout the world. Ideally, Private Enterprise, Inc., puts up 25 percent of the money, a bank puts up 25 percent and a local entrepreneur or investors, who manage the project, finance the balance. Together, they provide capital never before available and realize close to 100 percent on successful ventures.

The State Department views Bill's venture into the international field with occasional alarm because his actions are not accompanied by ten carbon copies and an act of Congress. They are reassured of PEI's value and virtue by the implacable enmity of Radio Moscow.

Thus far, there has been but one failure, and that was in this country, which PEI has earmarked for but 10 percent of its investments. "That," Bill relates with gusto, "came when we backed a plan to raise chickens in an abandoned salt mine. It was a good idea, but the chickens didn't like it!"

Bill, the man, is a lean, brown and hard five-foot-nine. Alert and restless, his decisions give the illusion of being instantaneous, but it is the general opinion that "he figures these things out while the rest of us sleep."

That is probably true. Since his birth 49 years ago on a small farm near El Dorado, Kansas, he has been the personification of private enterprise. His driving ambition is to excel.

That drive carried him through Northwestern University

WILLIAM L. GRAHAM

Graham-Michaelis Drilling Company

with odd jobs and a flare for selling a razor blade sharpener; and it netted him a charming wife, Marge, whose cool practicality, and sense of humor serve as an important governor when Bill's enthusiasm carries him beyond the limits of mortal endurance.

Together they went into the real estate business in Wichita at a time when realtors considered starving an easy way out. They kept score with a graph until they literally ran out of paper. By then, Bill had built a thousand houses and had title to several hundred apartments. He had been assured that all of those ventures would fail.

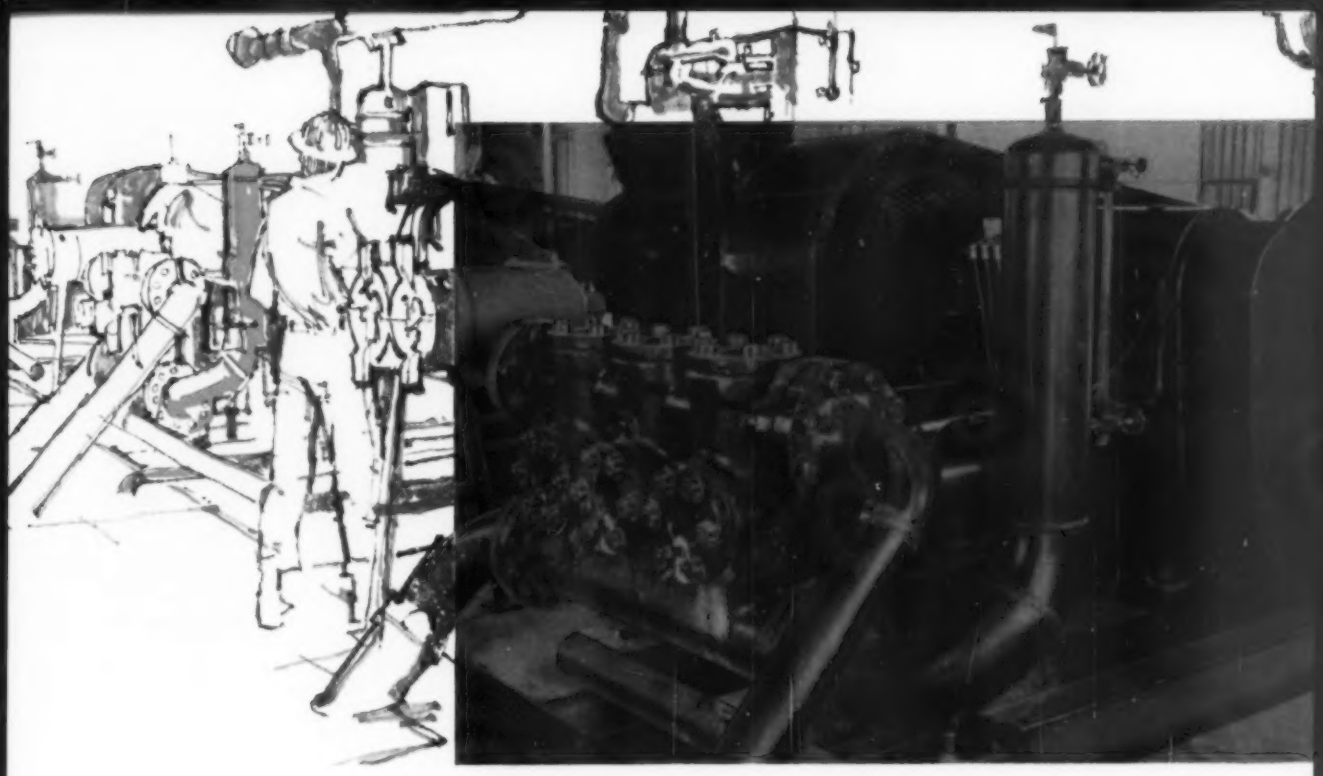
He started liquidating his real estate and went into the oil business in 1947, when, his friends assured him, he was suckered on a $30,000 lease deal. The price of oil went up, additional production was developed.

Later he started "paying far too much" for gas properties. It was but a few years later that rising gas prices and prorated oil made his switch a bargain.

He disclaims personal credit for success in the oil, gas and drilling business. "Pick business associates smarter than you are," is one of his maxims, and his judgment in picking winners has been unerring. He gives them a 50-50 deal with an option to buy or sell the partnership at any time.

Even the pleasures of home and family are often interrupted by business, and Bill's flare for a good deal is never more evident than when he turns to Marge — "Honey, which would you rather have me do: help you dry these dishes or go get on the phone with an idea I just got and make $100,000 for PEI?"

Marge drys the dishes. She knows that Bill may do just that.



4-inch stroke triplex plunger pumps in waterflood service near Clay City, Illinois.

6-inch stroke triplex plunger pumps in a waterflood installation in the bayou country of Louisiana.

8-inch stroke quintuplex plunger pumps on the world's largest waterflood at Long Beach, California.

When big pumps are too big and small pumps are too small...here's the "flood" pump you need!

This "Oilwell" 8-inch triplex pump is exactly right for those "in between" waterflood pumping jobs. This is a rugged, horizontal-type pump with large access openings for quick and easy maintenance.

Operating at 200 rpm, this pump can handle 23,600 barrels per day at 600 psi or 5,890 barrels per day at 2400 psi. This wide volume-pressure range is made possible by a selection of three fluid ends. The high-pressure fluid end is used for the 2400 to 1400 psi range; the medium-pressure end, 1600 to 1000 psi; the low-pressure end, 1000 to 600 psi. These fluid ends are aluminum bronze for corrosive service or of other materials for special pumping requirements.

There's a wide range of "Oilwell" pumps for waterflood applications. You can get complete information at your nearest "Oilwell" store or from your "Oilwell" representative. Call him today.

USS and "Oilwell" are registered trademarks

USS Oil Well Supply Division of United States Steel

Executive Offices—Dallas, Texas
Export Office—30 Rockefeller Plaza, New York 20, N. Y.

the conference table

Down But Not Plumb Out

The Newsweek issue of June 27 had the oil industry hanging on the ropes. General Editor Sanford Brown appeared to believe that it is all over but carrying out the corpse. We do have problems and problems galore. As you look back there's never been a time when the industry did not have a good-size bundle of them.

The article had as much imbalance as that between supply and demand in the oil industry. Everything was on the heavy side and, really, it is not true that: "The Russians

"The great human advances have not been brought about by mediocre men and women."
— Herbert Hoover

with no concern for profit margins, dumped some 16 million tons of oil a day into free-world markets at depressed prices during 1959 and are stepping up their marketing drive."

Sixteen million tons a day would be about 120 million barrels of oil. Since the whole world uses about 100 million barrels less than that, we would be swimming in oil if it were true. However, it was a natural error. The actual fact is that Russia dumped some 16 million tons of oil during the whole year of 1959.

Russians Quit Baghdad Refinery

About the time that Castro took over the three refineries in Cuba, those of Texaco, Esso and Shell, the Mid-East Commerce Petroleum News came in and its main story predicts what will happen next in Cuban oil.

Do you remember last year when the Iraq revolution threw out American and British personnel at the Daura (Baghdad)) refinery? Less than a year later, the Iraqi Administration gave the Russian technicians who were handling the plant sudden notice to withdraw and American technicians were brought in to run the installation.

The article in the magazine, which is published in Beirut, said that the reports were the technicians were happy to be relieved of the responsibility of operating the refinery. The equipment and processes involved are of the latest Western types, said the report, and the Western petroleum industry, in its major technical aspects is known to be in advance of Russian practices at the present time. It is, therefore, not unlikely that the Russians would find it virtually impossible to remain in control of a complex organization with which they were completely unfamiliar, and also being in the position of having to train Iraqi technicians for senior technical positions there, some of whom had already achieved a high standard of theoretical and practical knowledge.

"England and America are two countries separated by the same language." — George Bernard Shaw.

From Sense to Nonsense

An 18-year-old girl caused 400 workers to go on strike at a textile plant in Guisborough, England. Management claimed that her short skirt was distracting to male employees and asked her to wear a longer skirt. She took the matter up with the union and the union walked out on strike. Whimsy is displacing common sense as the first principle of business.

A Must for Reading

There is so much discussion based on shaky statistics about economic growth and economic competition between the U. S. and Russia. If you want to clear out the undergrowth of tangled figures and spongy analysis, be sure to read the speech by W. Allen Wallis, special assistant to President Eisenhower and executive vice chairman of the Cabinet Committee on Price Stability for Economic Growth. The address was given before business and financial journalists.

An economist needs most to have the terms we use in gauging economic growth clarified and limited. For instance, real Gross National Product from 1909 to 1957 grew at an annual compound rate of 2.9 percent per year, real GNP per capita, during the same period, increased annually 1.5 percent. Many of the percentage increase figures that are so carelessly tossed about include inflation. Mr. Wallis also explains the difficulty of obtaining logical comparatives. He provides laymen with a good basis for economic understanding.

You can get a copy of the paper, "Economic Growth: What, Why, How," by Mr. Wallis by writing him at the White House and requesting a copy.

"America is the country where you buy a lifetime supply of aspirin for one dollar, and use it up in two weeks." — John Barrymore.

Standard Indiana Joins Reorganizers

Standard Oil Company (Indiana) plans an extensive corporate reorganization, effective January 1, 1961. Chairman Frank O. Prior and President John E. Swearingen told stockholders that "the purpose of the plans . . . is the increased profitability of your company." They said the reorganization will:

1. Make Standard Oil (Indiana) exclusively a parent company concerned with broad management policy and with the coordination of subsidiaries that deal with all aspects of the oil business. The parent company will have

Exclusive LUFKIN Chrome Clad® lines defy grit, grease, gravel—and rugged use!

Here are "he-man tapes" that work like troopers when the job's toughest!

Easy-to-read markings will *stay* easy to read, because they're bonded to steel, electroplated and chrome coated. Lines won't kink or break. Sturdy metal construction (except for carrying handle). It all adds up to two-fisted quality that *lasts!*

Exclusive quality features are yours in *all* Lufkin tapes. For example:

Lufkin Chrome Clad® DERRICK Tape (above, left) gives you instant readings on a line that won't rust, chip or peel. An extra-sturdy line, ¼" wide, with hook and ring. Lock-handle frame. Turn handle over, lock line at any point. Available in 100-200' lengths.

Lufkin "ATLAS" Gaging Tape (above, right) gives you easier reading, too, with durable, jet-black markings on glare-free line. Line is 50% heavier than standard. Has 20-ounce plumb bob, and sturdy lock-handle frame.

See your Oil Supply House.

Measure for measure, the finest made...

LUFKIN

SAGINAW, MICHIGAN

no direct operating assets such as it now has in the Midwest.

2. Combine all product refining, transportation, and marketing operations and assets of Standard and its wholly owned subsidiaries, Utah Oil Refining Company and The American Oil Company, in a single company with unified management. This company will be American Oil. L. W. Moore, now president of American Oil, will continue as president and chief executive officer.

Under the proposal, Mr. Prior and Mr. Swearingen said the parent company will be "better able to concentrate on over-all policy guidance, coordination of operations, evaluation of performance, and planning for future growth."

Mr. Swearingen will be president and chief executive officer of the parent company. The office of chairman of the board will be discontinued on the retirement August 25 of Frank O. Prior.

Hardly Anybody Is Anti-Antitrust

In the June issue of Fortune, Ruth Sheldon Knowles has an article on antitrust affairs. She begins with the litigation against 29 oil companies charged with fixing prices and takes the reader through recent history of the Justice Department's erratic procedure in antitrust cases. As Mrs. Knowles says, businessmen must strive to be on the alert until antitrust issues are fought out in the open rather than conducted by guerrilla warfare.

Although the antitrust policy of the Justice Department is felt in industries outside the oil industry, we seem to get the biggest share of the attention. In some vital areas the Justice Department is in much greater control of business than the law seems to require.

Benedum's Philanthropies Go On

Greystone, for nearly half a century the home of the late Michael L. Benedum, will become a part of the campus of Chatham College, Pittsburgh, Pennsylvania. The gift was made in honor of Mr. and Mrs. Benedum and was presented to the school through the Claud Worthington Benedum Foundation, which was organized in 1944 to carry on philanthropic work as a memorial to the Benedum's son who died in World War I. Paul G. Benedum (nephew) and his wife made the presentation. The property includes eight acres of ground and additional buildings.

Oil Gals to Meet

"Horizons Unlimited" has been selected as the theme for the ninth annual convention of the Association of Desk and Derrick Clubs of North America to be held in Detroit, Michigan, September 23-24. Approximately 1000 members, representing the 115 clubs in the United States, Canada, and Hawaii, are expected to be present when the two-day meeting convenes. Miss Gladys Watford, Houston, Texas, is president.

Propaganda Skirmish

All kinds of things turn up in the battle for public approval on fuel policy. We'd never had known there was such a thing as First American University Energy Institute if it hadn't been for the National Coal Policy Conference. The institute, it seems, met in Washington, D. C., the week of June 27. Now, we think universities should be interested in energy and we have been wondering what the oil and gas industries had to say to this American University Energy Institute. Dr. Glen L. Parker, economist of the National Coal Policy Conference, said the same things he's been saying. He said, "Any government policy which results in subsidizing the inefficient or in any way contributes to a situation in which any energy is being sold at a cost to the user which is less than the input cost is an uneconomic policy, and is an unsound treatment of private enterprise."

Then the coal industry's spokesman suggested these areas a Congressional study of America's fuels economy might cover:

Reviewing the current operation of the fuels industries to see how "the large number of laws, regulations, and policies arrived at on a strictly *ad hoc* basis are working and in what respects various policies may be working at cross-purposes."

Reviewing the prospective future energy requirements of the nation.

Reviewing the basic energy sources to determine how future requirements may best be met.

Reviewing "the whole problem of interfuel competition with the idea of developing competitive ground rules."

Reviewing the problem of the degree to which the United States can allow its energy needs "to be met by low-cost foreign energy as opposed to more expensive energy from domestic sources.

"No man is impatient with his creditors." — Talmud.

Early Annual Reports

Douglas Oil Company profits came back into the black in the year ended March 31, 1960. Loss for the year ending 1959 was $436,102 and the earnings for the year ending 1960 were $1,012,585. Sales were 2% higher. Cash flow almost doubled to $2,000,000.

Superior Oil Company saw a 19% drop in net income for the first nine months ending May 31. Earnings in 1960 were $18.5 million compared to almost $23 million in 1959. Revenues were down only 6%. Lease abandonment expense was almost 15% higher in 1960 than in 1959.

Ocean Drilling & Exploration Company made a preliminary report of net for the year ending May 31, 1960 of $520,000. This is a marked improvement over 1959 which showed a net loss of $431,000.

Atlantic Refining Company earned about $4.8 million in April or May with an estimate of $2 million for June. Atlantic's first half profits should be about $15.5 million, down from earnings of around $17.3 million in 1959.

Tekoil Corporation set new records. Its gross income of $2.5 million was up nearly 15% in the year ending March 31, 1960. Both 1959 and 1960 annual reports showed a net loss. The loss this year was $686,000 — slightly less than that for the year ending March 31, 1959.

World Production of Carbon Black, by Countries,[1] 1955-59, (Thousand pounds[2])

Country[1]	1955	1956	1957	1958	1959
Brazil	(3)	(3)	30,864	68,929	134,128
France	8,818	9,259	8,818	8,818	8,800[4]
Germany, West	122,624	127,122	149,670	141,429	(3)
Japan	16,667	25,159	30,611	31,662	(3)
Taiwan	589	603	680	(3)	(3)
United Kingdom	170,016	182,784	234,035	243,936	269,069
United States	1,743,512	1,839,968	1,798,425	1,644,605	1,967,527
Yugoslavia	2,837	3,602	4,242	4,934	6,440

[1] Canada became a producer of carbon black in 1953, with completion in June of a oil-black furnace at Sarnia, Ontario, having a capacity of 20 million pounds per year. The capacity was increased to 60 million pounds in 1956. The actual production is not published to avoid disclosing individual company confidential data.
[2] This table incorporates some revisions.
[3] Data not available.
[4] Estimate.
SOURCE: Foreign Statistics, Division of Foreign Activities, Bureau of Mines.

Good Wells Make Good News

A Report on Profitable "Workover" Treatments by Dowell

August, 1960

Workover treatments of old wells frequently yield more net profit than new wells if treatments are designed for reasonable cost and fast payout. Here are four examples of fast-payout treatments:

- **McKenzie County, North Dakota** (Old Oil Well) Production from this Madison lime well had declined to 35 bopd. Completion was through perforations from 8500 to 8590 feet. Dowell used the "Acid Guide"* to engineer the following treatment: 7000 gallons of acid-oil emulsion type Retarded Acid were injected down tubing at 5.4 bpm and 2100 psi. Production rose to 133 bopd and the $3101.00 treatment paid out in 23 days.

- **Ventura County, California** (Old Oil Well) This well had been completed through perforations into the "G" sand from 8174 to 8336 feet. Production had declined to 38 bopd pumping, and re-perforating did not help. Dowell fractured the well using 50,000 gallons lease oil and 40,000 pounds sand. Treatment was down casing at 30 bpm at 4000 psi. After treatment well flowed 500 bopd through casing and declined to 300 bopd before tubing and gas lift valves were installed. Production is now 175 bopd—gas lift. The $5100.00 treatment cost was paid out before tubing was run.

- **Grant County, Kansas** (Old Gas Well) This well had been producing from the Hugoton series through perforations from 2451 to 2697 feet. Deliverability had decreased to 674 mcfd. Dowell fractured using 100,000 gallons fresh water and 86,200 pounds sand. Injection rate was 57.2 bpm at 500 psi maximum. 490 ball sealers were used during treatment to assure stimulation of less permeable sections. After clean-up, deliverability rose to 2146 mcfd. The operator estimated a 7-month payout on the treatment which is considered excellent for the area.

- **Plaquemines Parish, South Louisiana** (Old Oil Well) Production from this Miocene well had declined to 38 bopd. The operator wanted to stimulate production, but did not want to go to the expense of moving in a service rig. Dowell acidized through the Christmas tree with 1000 gallons Mud Acid. Treatment cost was only $930.00 and boosted production to 73 bopd. Payout time was 12 days.

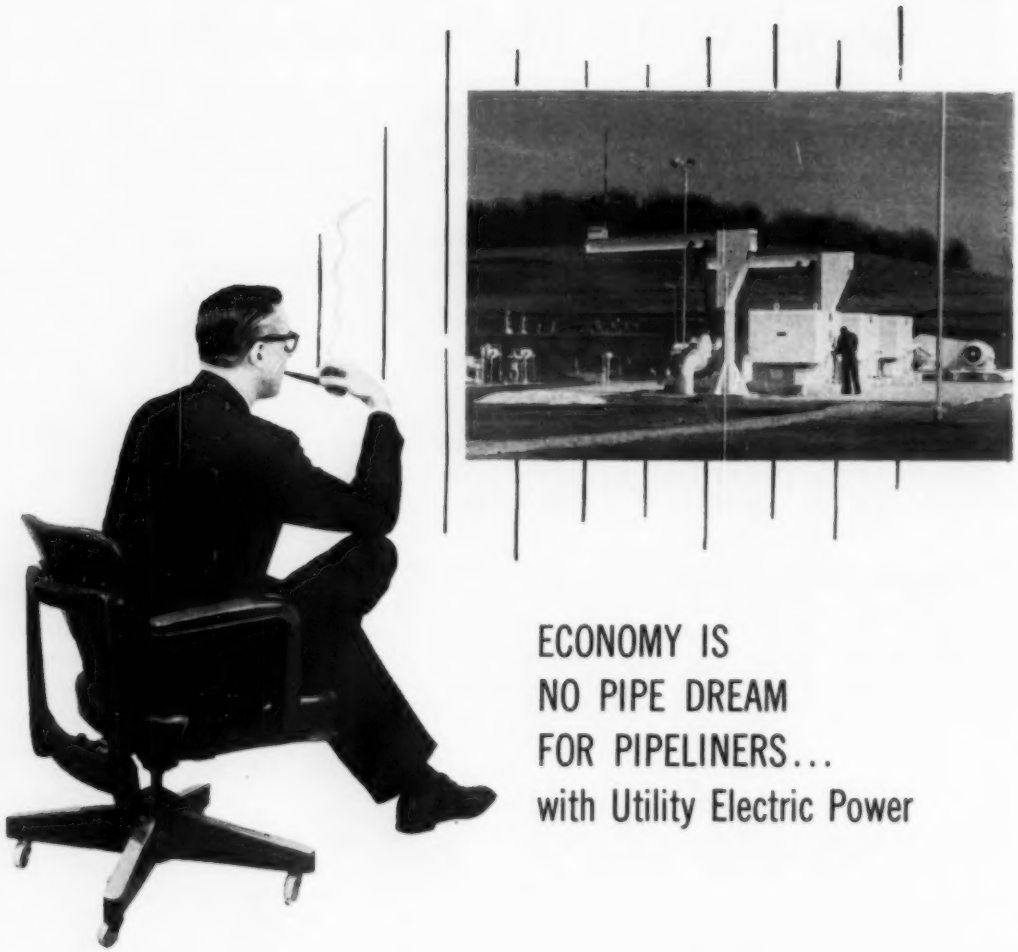
If you are caught in a profit squeeze, dial Dowell. A Dowell representative can go over your production picture and propose a program designed to increase your net profit with a minimum investment. Dowell services and products are offered from more than 150 offices and stations in the United States, Canada, Venezuela, Argentina and Germany. Dowell, Tulsa 1, Oklahoma.

*DOWELL TRADEMARK

Services for the oil industry DOWELL

DIVISION OF THE DOW CHEMICAL COMPANY

Memo to Management:



ECONOMY IS NO PIPE DREAM FOR PIPELINERS... with Utility Electric Power

Here is another pipeline installation utilizing economical utility electric power to move an amazing amount of crude each day. This major company knows the value of efficient electric power and why it gives them more dependable, more economical power service . . . when and where it's needed. Now is the time to analyze your power costs. For the facts on electric power savings consult your Utility Electric Power Company.

A list of P.E.P.A. members will be furnished on request

PETROLEUM POWER ELECTRIC ASSOCIATION

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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

SPECIAL REPORT TO CATERPILLAR OWNERS:

CAT CATERPILLAR

Parts you can trust
...cost less per hour

announcing...

BONDED BUY PARTS ASSEMBLIES

PARTS
BONDED BUY
ASSEMBLY

PARTS ASSEMBLY
Guarantee Bond

Know All Men by these Presents,

that _____

of _____ (hereinafter called Seller),

is held and firmly bound unto _____

of _____ (hereinafter called Buyer)

in the sum of not exceeding the lesser of FIVE THOUSAND DOLLARS ($5,000.00) or Seller's price, with respect to each parts assembly described below, for the payment of which Seller hereby binds itself, its successors and assigns by these presents.

The Condition of this Obligation is such that Whereas Seller has sold to Buyer the below-described parts assembly or assemblies originally manufactured by Caterpillar Tractor Co. and reconditioned in accordance with practices recommended by Caterpillar Tractor Co.:

DESCRIPTION	PART NUMBER	SERIAL NUMBER	SALE PRICE

And Whereas Seller guarantees each said parts assembly against unsatisfactory performance due to defective material or workmanship for _____ days after the date of sale shown below (herein referred to as the guarantee period), the obligation under this guarantee being only to repair or replace, as Seller may elect, any said assembly which proves defective in material or workmanship under conditions of normal use during the guarantee period at Seller's expense (including cost of all necessary materials and labor) up to a maximum of the lesser of Five Thousand Dollars ($5,000.00) or Seller's price, with respect to each said assembly, except that the cost, if any, of transporting each said assembly from and to Seller's place of business shall be paid by the Buyer.

Now, Therefore, if Seller, its successors and assigns shall in all respects well and truly perform the obligation under the guarantee recited above, then this obligation shall be void, otherwise to remain in full force and effect.

THE ABOVE GUARANTEE IS VOID, AND SELLER SHALL BE UNDER NO OBLIGATION THEREUNDER, IF CLAIM IS NOT MADE TO THE SELLER WITHIN THREE (3) DAYS AFTER DISCOVERY OF THE DEFECT UPON WHICH THE CLAIM IS BASED.

You can have complete confidence in any Parts Assembly Exchange or Rebuilt Unit carrying the dealer's new Bonded Buy label. You'll receive a Guarantee Bond, backed by the Lumbermens Mutual Casualty Company of Chicago, Illinois, giving the guarantee conditions agreed upon at time of sale. This is further evidence that a Caterpillar Parts Exchange or Rebuilt Assembly is in first-class condition—another way of expressing the careful and thorough workmanship that goes into each of these reconditioned assemblies.

The cost? It compares favorably with the cost of doing the reconditioning work yourself. Often less . . . because of the availability of special equipment and servicemen's skills in the dealer's shop. Your final net cost is based on parts and labor necessary to put your worn assembly in A-1 condition—same as the exchange unit you receive.

Here's why Cat Reconditioned Assemblies save you money. You trade down time for more *go* time. Simply:

1. **Call your Caterpillar Dealer and arrange for the Parts Assembly you need.**
2. **Remove your worn assembly and install the reconditioned unit.**
3. **Put your machine back to work immediately and return the worn unit to your dealer.**

Any way you look at it, a Bonded Buy Parts Assembly is a good deal. You get a dependable unit . . . guaranteed in writing. The cost is approximately the same had you done the work yourself. Time saved can be converted to cash because your machine's working and earning. Contact your Caterpillar Dealer today. Find out what assemblies he stocks (new items are being added daily).

SERVICE TIP: Never allow your present machine components to become worn to the point where reconditioning is impossible.

CATERPILLAR

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Caterpillar Tractor Co., General Offices, Peoria, Ill., U.S.A.

INTRODUCING Poxyglas™

the ALL-NEW type of tank for handling all corrosive fluids common to Oilfield Production!

- ✓ **Sour Crude**
- ✓ **Salt Water**
- ✓ **Fresh Water**
- ✓ **CO_2**
- ✓ **H_2S**
- ✓ **Treating Chemicals**

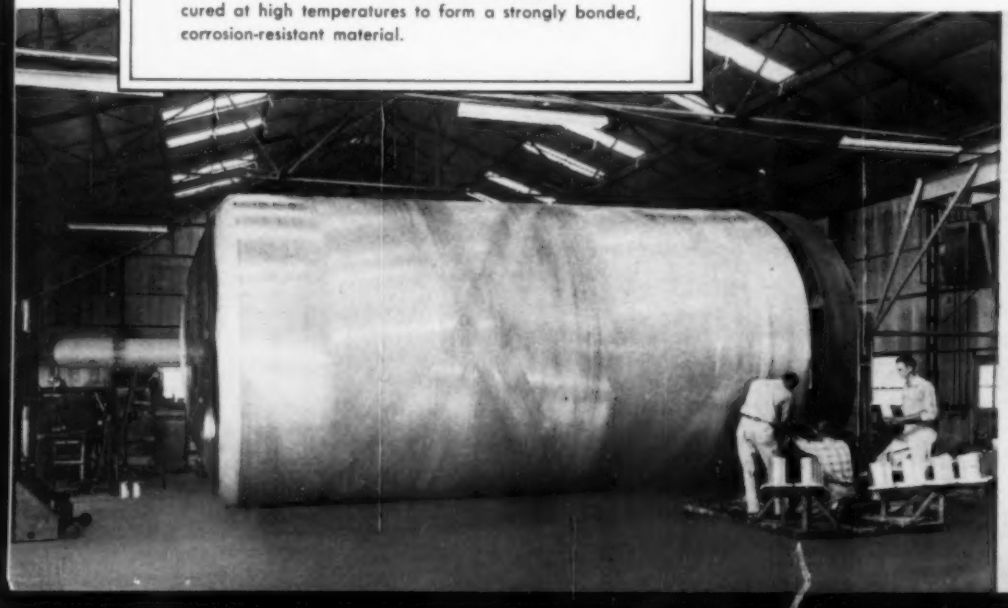
Also ideal for areas where *EXTERNAL* corrosion is a problem . . . or where tank weight is a factor!

WHAT IS *Poxyglas?*

POXYGLAS is BS&B's new corrosion-resistant, high strength, light weight glass-resin material that utilizes a filament winding process. Glass filaments are impregnated with epoxy resin and wound in a precisely controlled pattern onto a mandrel. The catalyzed resin is cured at high temperatures to form a strongly bonded, corrosion-resistant material.

BS&B's Filament Winding Method Has These Important Advantages Over Conventional Methods Of Reinforced Plastic Tank Fabrication:

1. **Tank diameters are consistent** because tanks are wound and cured on steel mandrels. No strapping of tanks necessary. Exact volumes of tanks can be calculated.
2. Filament wound structures are *3 to 4 times as strong* as conventional reinforced plastics. Continuous high strength glass filaments carry the load, thus eliminating plastic creep.
3. Completely *controlled glass pattern*. Glass filaments are wound under tension onto a mandrel in a calculated pattern for maximum strength.
4. **Consistent glass-to-resin ratio** is insured by controlled glass impregnation. Every fila ment is thoroughly covered with epoxy.
5. **Production type operation.** BS&B winding machines have high winding rates with maximum versatility and performance capabilities.
6. **Epoxy-rich inner layer** of the tank eliminates "wicking action", gives a 100% corrosion-resistant inside surface.



POXYGLAS tanks are wound on mandrels controlled by a programmed electro-hydraulic servo system developed by BS&B.

This battery of two 12' x 20' POXYGLAS tanks is used to handle corrosive crude.

WHY *Poxyglas*?

Lowest in cost for true corrosion protection....

POXYGLAS combines corrosion-resistant glass and corrosion-resistant epoxy with filament winding to produce a tank that will handle all types of corrosive oilfield service and many chemical plant services where corrosion or product contamination are problems.

Absence of corrosion means low maintenance....

Inspection and recoating costs are eliminated.

POXYGLAS is light weight and has high strength characteristics....

POXYGLAS tanks are approximately one-eighth the weight of a comparable steel tank. Strong, lightweight tanks can be handled with a minimum amount of equipment. Easy to move and reset.

Competitively Priced....

POXYGLAS tanks cost less than redwood tanks, and are competitively priced with welded steel tanks that have been internally coated for corrosion resistance.

POXYGLAS TANK SIZES

Tank No.	Capacity Barrels*	Diameter Feet	Height Feet	Approximate Weight
45-05-001-01	110	10.	8.	900
45-07-001-01	200	12.	10.	1050
45-05-002-01	210	10.	15.	1050
45-05-003-01	280	10.	20.	1350
45-07-002-01	300	12.	15.	1300
45-07-003-01	400	12.	20.	1500

* 42 gallon barrels.

STANDARD FITTINGS AND ACCESSORIES

1 — 4" Gas Equalizer
1 — 4" Fill Line
1 — 4" Vent Line
1 — 4" Drain
1 — 4" Pipe Line
2 — 4" Overflow
1 — 8" TF92G-PB Thief Valve
1 — 18½" x 14" Elliptical Manhole

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There's a Place For ***Poxyglas*** *in Your Operations!*

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Do you know the answer to this question?

Q. Which is taxed at a higher rate—

a fur coat? **OR** gasoline?

A. The tax rate on gasoline is almost 5 times as high!

Some other "gasoline tax" answers you should know!

Q. What's the average federal and state tax on ten gallons of gasoline?

A. About one dollar!

Q. How much have gasoline taxes increased in the last ten years?

A. About 51%! (But the price of gasoline itself has only increased 5.5%!)

Gasoline's a buy...only the tax is high!

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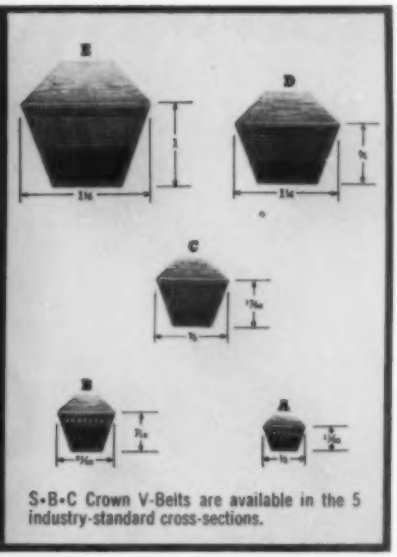
New from Skinner Brothers—

YOU GET MATCHED V-BELTS EVERY TIME WHEN YOU SPECIFY S·B·C CROWN BELTS

SKINNER BROTHERS INTRODUCES ITS OWN RUGGED BRAND OF V-BELTS WITH A GUARANTEE OF LONGER LIFE AND TROUBLE-FREE PERFORMANCE

1) Rubber in stress section is specially compounded to remain cool under constant stretching and flexing. 2) Tensile cords are wound in continuously under electronically controlled tension, assuring even distribution of load. 3) Rubber in compression section is compounded to provide even load distribution. 4) Elastic-weave jacket fabric insures easy flexing — special treatment reduces sheave wear.

S·B·C Crown V-Belts provide minimum stretch, dimensional stability—equal load.



S·B·C Crown V-Belts are available in the 5 industry-standard cross-sections.

Today you can get perfectly matched V-belts from your supply store without delay!

No wasted time over a matching machine – no worries about down-time because of improper match. Result: faster installation, trouble-free operation, longer belt life.

S·B·C Crown V-Belts – newest in Skinner Brothers' expanding line of quality equipment – are backed by the same guarantee of service and satisfaction that has been an oil patch tradition for nearly half a century.

The belts themselves are the finest that can be produced: the most modern synthetic fibers and highest quality rubber compounds are used. Precision manufacturing methods insure uniform tensile strength, elasticity and dimensional stability. *Quality* is built in – *service* comes with S·B·C's tradition for follow-through.

NEW S·B·C CROWN V-BELTS GIVE YOU THESE OUTSTANDING FEATURES

- Perfect match – beats API specifications
- Smooth shock absorption – rugged construction that takes punishment
- Low stretch – equal load distribution for efficient, constant power
- Low maintenance – less down-time speeds up operating schedules
- Every belt fully backed by famous Skinner Brothers service policy

SKINNER BROTHERS COMPANY

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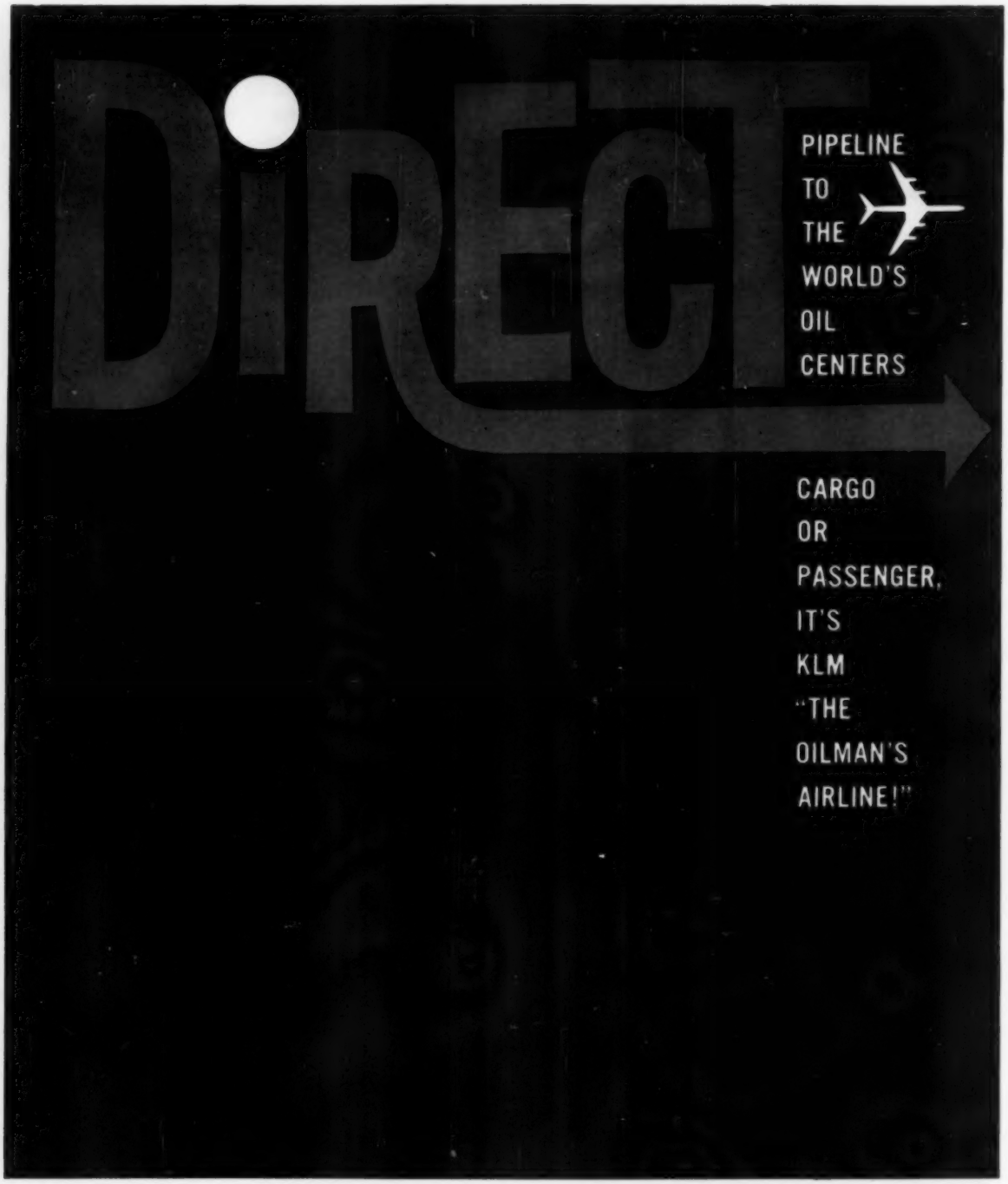

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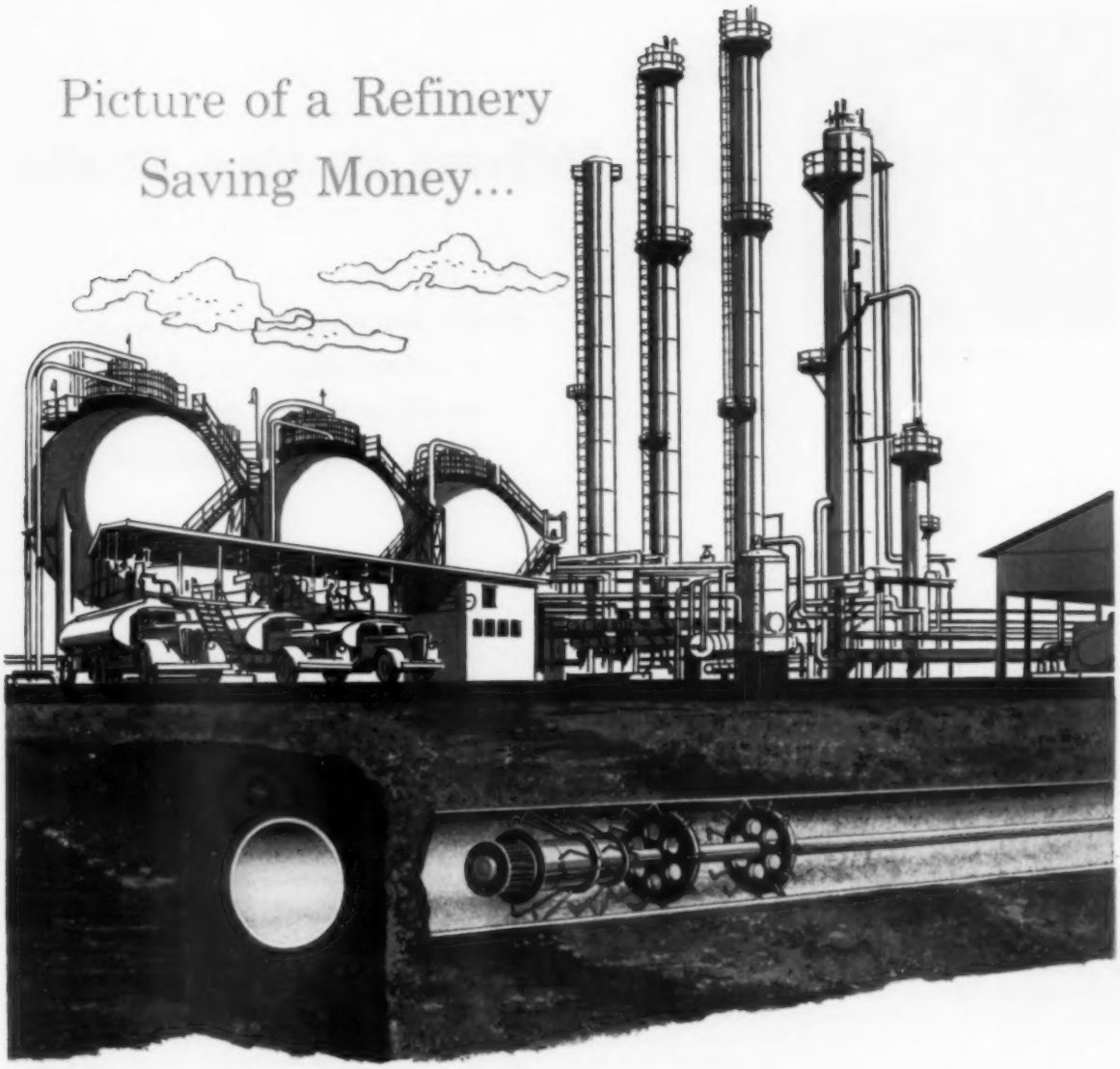

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Gordon Simpson

What is the Role

"Producer drills 80 to 85% of wildcats — shares risks," says Gordon Simpson, President, General American Oil Company of Texas.

THE FUTURE OF OUR COUNTRY and the world is tied closely to energy use. Petroleum fuels will be the dominant source of energy for the foreseeable future.

In just the next 10 years, United States population will rise 32 percent while per capita consumption of petroleum fuels (oil and gas in oil equivalent) will increase to 1550 gallons by 1970 — a rise of 20 percent per person.

Total oil demand will rise to 12.5 million b/d by 1970, an increase of 25 percent.

If we continue to drill 5 to 5.6 wells per million dollars of income (postwar range of drilling) completions in 1970 would total somewhere between 65,000 to 70,000 wells.

Assuming that U. S. oil production expands in line with demand, and imports are permitted the same relative portion of the market they now fill, U. S. production in 1970 should rise to about 10.9 million b/d. Production of this order would generate income of about $13 billion in 1958 dollars.

Demands of the 1960's will require production of 40 billion barrels. To meet this increasing demand, and maintain a ratio of reserves to production on the order of that now existing, means the industry in the United States will be required to find and develop 54 billion barrels of new oil by the year 1970.

This challenge must be met if our country is to maintain an energy so obviously required. As President Eisenhower has said, an adequate oil supply is an essential and primary "deterrent" to war.

As in the past, the lion's share of our future oil will be found by independent producers. Independent producers, as contrasted with integrated companies, traditionally have drilled 80 to 85 percent of exploratory wells in the United States.

Future availability of oil in the United States will be determined largely by these vast numbers of producing companies. If their activities suddenly were to cease, our supplies of a basic munition would dwindle away, and our country would be in dire danger.

The oil producer who survives and succeeds in 1960 must be blessed with more varied attributes than his counterpart of years gone by. There was a time when the "typical" oil producer was one who came up as a rig hand, who frowned on geology or used his own system of "creekology" but who, nevertheless, found his share of oil.

Today the independent producer is more likely to be an engineer or geologist. If he isn't trained in industry sciences, he leans heavily on those who are. He not only employs the sciences in searching for oil, he must use them in recovering the oil he finds.

In addition, he must be more cost conscious than ever — because drilling and development costs continue to rise, and the price of his product trails behind these ever-rising costs. The producer's costs are compounded not only by greater real costs of wages, materials and services, but by the constant necessity to drill deeper and in more obscure places.

One essential that is unchanged in the producers' operations is freedom of action, and flexibility. He must be able to create opportunity where he can, recognize opportunity when he sees it, and grasp opportunity on a moment's notice. In the search for oil, time and tide indeed wait for no man.

One of the great misnomers of our time is the term "independent" as applied to the small oil producer. Few business men are less dependent on others. With drilling costs and risks greater than ever, few are those who can drill any but the most attractive exploratory prospect on a "straight up" basis. Risk sharing is an ever-widening practice in today's wildcatting operations.

The financial resources of most independent producers is limited. In their operations, they are dependent on a sound credit position at the bank, on other financial sources outside of the industry, and on the support of major integrated companies through farmouts and financial aid in various forms.

But despite his dependence on others, the independent producer cannot wait for tomorrow. His plans are based on his judgment as to what can and must be accomplished within his lifetime. In contrast, the public-owned integrated company plans its operations on a basis involving contracts extending to the year 2000 and beyond.

While the bigger companies may be the better risk, the thousands of independent producers represent this country's source and assurance of the great bulk of its petroleum supplies for the future.

Given the benefit of a reasonable economic climate and consistent government petroleum policies, they will continue to find and make available adequate petroleum supplies to meet our requirements for the foreseeable future.

EDITOR'S NOTE: These are condensed versions of panel statements at Independent Petroleum Association of America at 1960 midyear meeting.

of the Independent?

Reid Brazell

"Refiner depends on mobility and flexibility," says Reid Brazell, President, Leonard Refineries, Inc.

INSTEAD OF INDEPENDENT, we should be called "dependent" refiners, for we depend on so many different things. First, we depend on ourselves to have the ability, the insight, the mobility, flexibility and agility to avoid falling into the bottomless pits caused by the bombs dropped on our markets in the price wars that have raged throughout the nation for the past two or three years. I want to hasten to say, however, that I like to be known as an Independent. At least, it indicates that I am not a person who has to depend on a lawyer or a committee to tell me what I am supposed to think. Or say.

What is an "independent refiner?"

He is, for the most part, a manufacturing merchant — sometimes integrated — usually not to any great extent, who buys his raw material, crude oil — usually from a major oil company — refines the crude oil into quality products and sells the products through independent jobbers.

How is the independent refiner presently doing profitwise?

Generally speaking, he is having a hard time. Product prices are down and costs are up.

Does the independent refiner want low crude prices?

No. He makes more money when markets are strong and crude oil prices are high.

Does the foreign crude oil import allocation assigned to the independent refiner cause him, or encourage him, to cut product prices?

No. Actually, in many cases, it is the only thing that permits him to stay in the black, or fairly close to it.

Why are product prices down and who is to blame?

The main reason is that the refinery runs are too high — resulting in more products being available than the market requires. Another reason for low product prices is the disposal of incremental barrel. The incremental barrel is the extra barrel that can be pushed through a refinery. *That is the cheapest barrel that is made in the refinery, but it is the most expensive barrel that any company sells because it is usually dumped on some market at a low price because it didn't cost as much to make as the other barrels.* As to who's to blame, all of the refiners must share some of the blame. True, some have reduced their runs, mostly the small independents. The majority of the blame, however, must rest with 15 or 20 of the large companies who process more than 80 percent of the crude oil run through the refineries in the United States.

How does the independent refiner continue to exist, let alone grow, in face of the fierce competition and the low product prices?

In addition to good sense and determination, the independent refiner takes advantage of his mobility, flexibility and agility. He watches the markets and the trends. He is small enough that he can change direction quickly, and he is constantly searching for new ways to better do his job. He is not bound by the red tape of committee operation and lawyer interference.

Take a cub airplane and a 707 jet . . . The man in the cub takes off from a very short field—it doesn't necessarily have to be paved—flies to his destination. Comes into a field close to the city, makes a short approach and lands in a few feet. Gets out and goes about his business.

The big jet requires a lot of personnel and a very elaborate field from which to operate. It requires very long runways — well constructed. When it sits down, the customers get off, wait a long time for their baggage before they are ready to do business.

The fellow that is in the cub has been on the ground doing business for quite a while.

Now, this story applies, of course, only on short hops. And, that is what the independent refiner tries to make — short hops.

How does governmental regulation affect the independent refiner?

It is deadly. When the independent refiner has to follow the set of rules dreamed up by some bureaucrats, use the same tools as the major, he is dead. In the first place, he can't afford the gold plating that the major puts on most of his facilities. In the second place, if he has to follow a set of governmental rules, he loses his mobility and flexibility, which is so vitally important to him.

What quality of products does the independent refiner make?

Usually, his products are equal to or better than those of his major competitors. He sells his products to those places and for those purposes for which they are best suited. The independent refiner has a constant struggle to find enough money to build and maintain equipment to keep in the front row of product quality. But he does it, thanks to the understanding and intelligence of our bankers.

I have tried to give you a very brief but, I think, a factual picture of an independent refiner. He takes great pride in living in and not on the industry — in being a good citizen. He has trials and tribulations in finding money to do the job, in battling against the ever-increasing economic pressures. He exists because of the hard work that he does.

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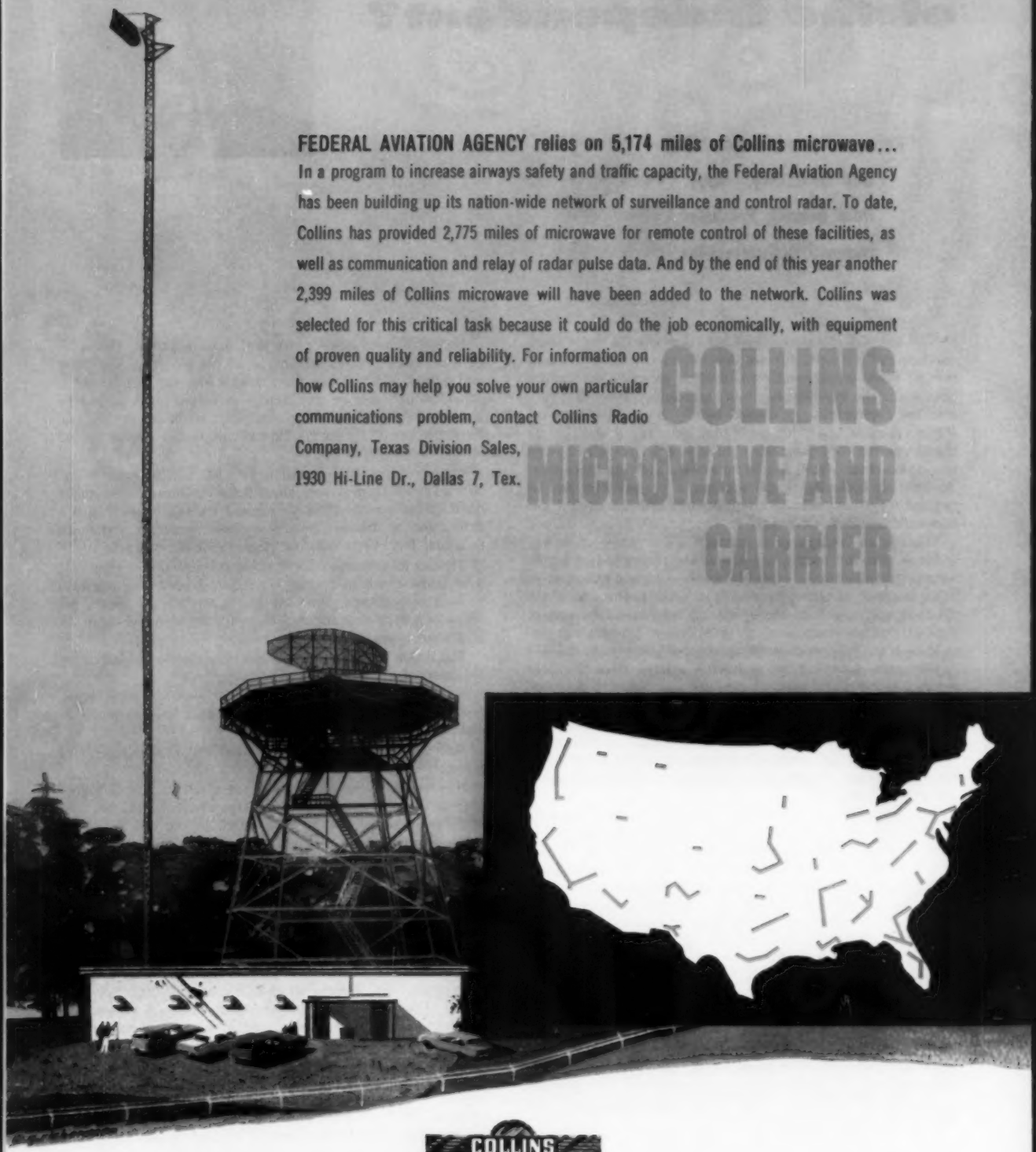

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In awarding Kellogg a lump-sum contract for the design, procurement, and construction of this alkylation unit, United chose a route that many refiners, both large and small, would find to be the shortest and most economical way to meet market demands.

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Kellogg sulfuric acid alkylation units are designed to minimize the use of costly materials and fabricating procedures. Yet they assure long life by reducing corrosion problems to a minimum without heavy use of expensive chemicals.

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Operation is Flexible

Kellogg units can operate on butylene, propylene, or a combination feed. In addition to producing high octane alkylate, they can produce an LPG product without supplementary towers or equipment.

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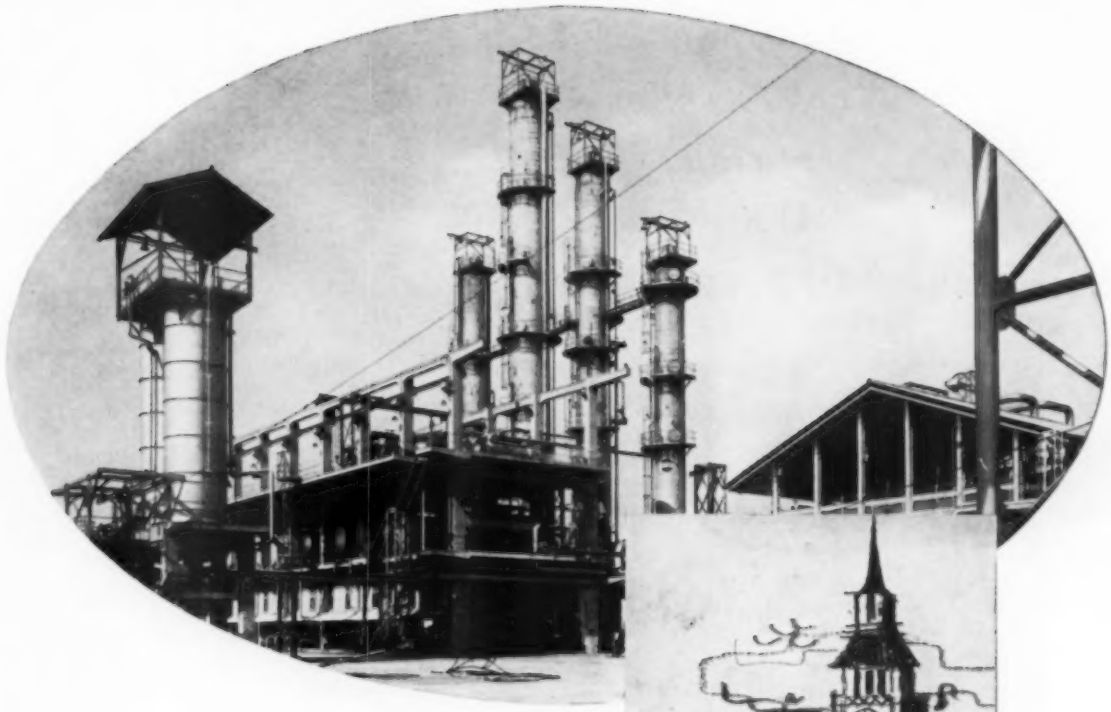

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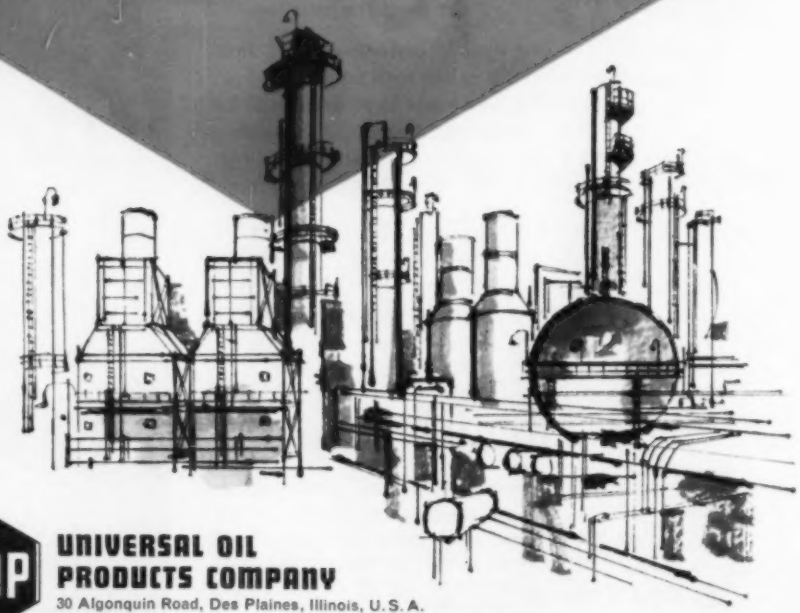

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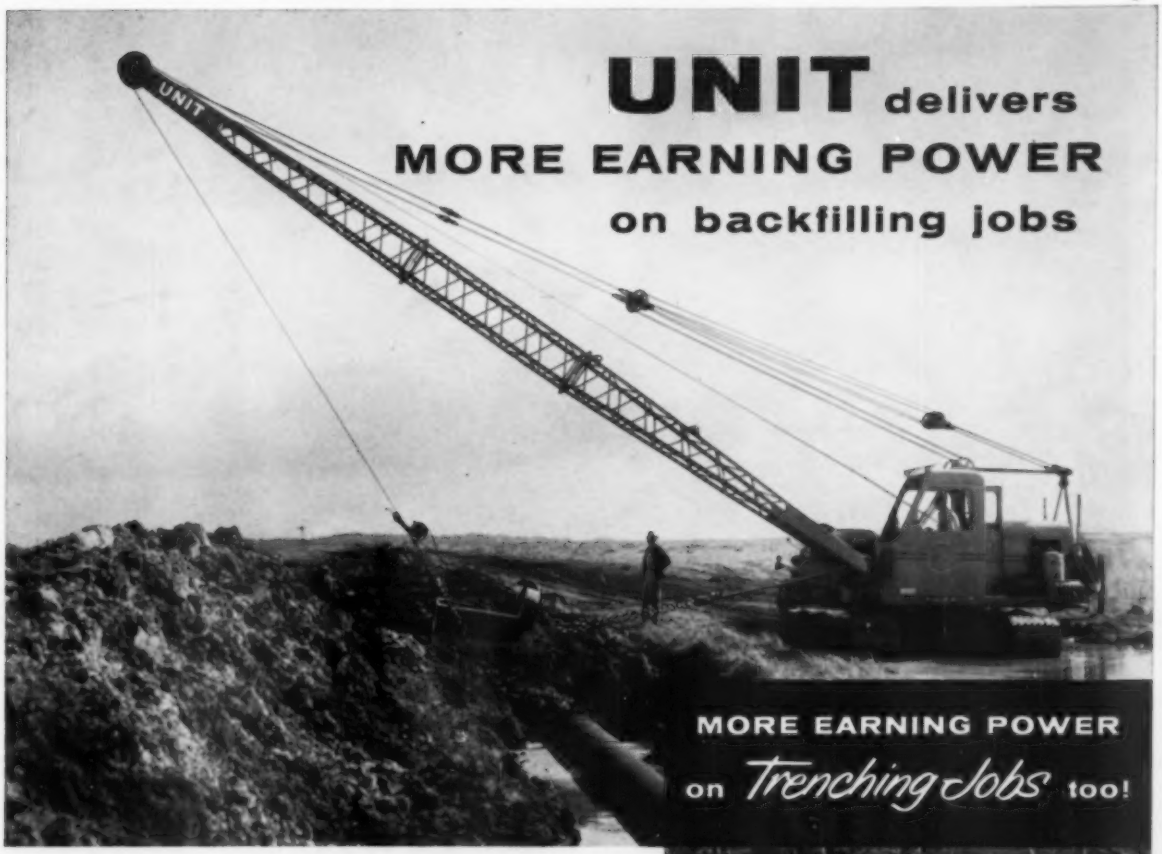

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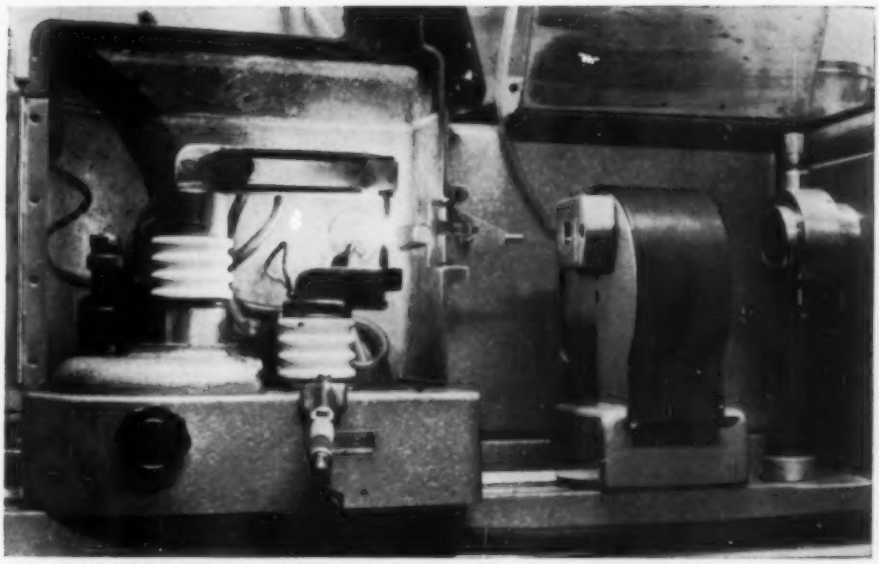

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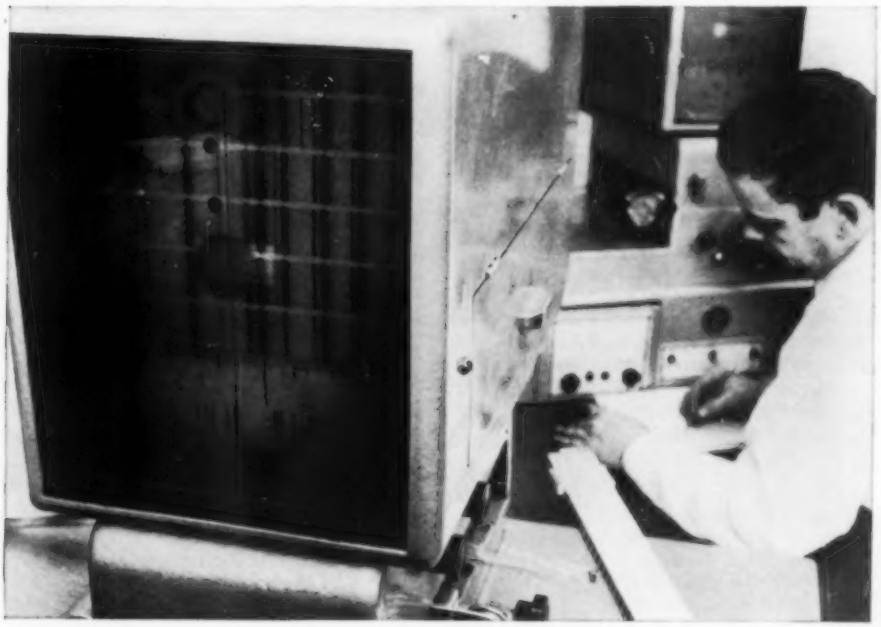

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What Makes a Good Executive?

An interview with Ray H. Horton

Good management in the petroleum industry today is a vital problem. Technology needs it to move its creative ideas into practical and beneficial use. Individuals need it to help develop their abilities and see the fulfillment of their talents. The corporate body needs it to keep in balance its operations and assure its progress in a competitive economy.

We went to one of the industry's most eminent examples of what a good manager should be. Professionally educated — as a geologist — Ray H. Horton (Humble Division president) has reached into all phases of his industry's management with receptive understanding. His natural friendliness is coupled with innate dignity. If you were applying for a boss, he's the kind you'd select.

Q. Mr. Horton, do you think the petroleum industry has advanced as far in management as in technology?

A. Technological advances have been tremendous — fabulous when you think of the methods and equipment used only a short time ago. It isn't surprising that the techniques of management haven't quite kept up. This can be laid to two reasons. First, we have put special emphasis on technical progress. It was so much more tangible and measurable than such a nebulous quality as management. And, second, dealing with people has no set rules. Even using methods we've learned can work with most people doesn't always produce desired results. Individuals simply don't conform to any pattern.

Q. If you had to choose between two men: One with broad education and one with specialized background — like geology or engineering — to develop into a manager, which would you choose?

A. Because of the nature of management, your decision would not rest on those factors alone. In fact, some of industry's most able leaders have had very little formal education. There are, moreover, certain imponderables of management and leadership which preclude laying down a law on general versus technological background. For example, some people are naturally inclined toward the assumption of management responsibilities. Others, when they are called upon to deal with people instead of material things, are not only less effective, but they also lose a great deal in the way of job satisfaction.

Q. What about the engineer or scientist that does not have managerial talents? Do you think they have a fair shake in the petroleum industry?

A. It is one of management's responsibilities to see that each individual's contributions to the organization are properly rewarded. Some technical specialists make great contributions to a company and to the industry, and they should be rewarded as well as management specialists. In addition, management should make every effort to provide the engineer or scientist with individual appraisement, help in self-development, and career guidance.

Q. Do you think the petroleum industry has good management?

A. Yes, but no industry ever has too much good management. There is always room for improvement, so we should try to learn everything we can about management skills and how to develop them. A constant challenge, for example, is the improvement of morale and the development of a sense of belonging in the supervisory and work force. That one duty, alone, presents a wide area of study for executives.

"No industry ever has too much good management."

Q. What then would you consider as basic qualities in selecting executives?

A. There are a number of basic qualities to be considered, but some that come most readily to mind are these:

First of all, the potential manager should have character and integrity. For the good executive, these are two essential traits.

He should be sensitive to people. He should realize that people have problems, and that everyone is different. For example, an employee who talks the least may have the best ideas.

He should be interested in people. An executive, through his own enthusiasm for the work at hand, may for a time enlist the support of others, but over the long term he must be concerned about the aspirations of his people or else he will eventually fail to inspire them.

He should have good judgment. It's hard even to guess how you can go about cultivating good judgment. Some people seem to be born with it. Experience, properly analyzed, may be one avenue. To enable him to make quick decisions and to improve his understanding of people and situations, the executive also needs a wide background of knowledge.

Not least of all, the executive must have the courage of his convictions — the courage to make decisions. In situation after situation, he must weigh the facts carefully and come to a quick decision. He must decide what to do and make it work.

"Dealing with people has no set rules."

"The executive must have courage to make decisions."

Q. You think these are the basic qualities of leadership?

A. These seem to me to be qualities that most good leaders have. Let me add that a title does not make a man a leader. Individuals become leaders when other people make them leaders by following them. And people follow a person when, either innately or through development, he demonstrates the qualities of leadership.

Q. That is an interesting observation — that leaders are discovered not so much by the people over them as by the ones below who are willing to follow them. But how can a man learn to be a leader?

A. Some people, of course, seem to be endowed from birth with the traits and qualities of leadership. Scores of examples could be cited from the pages of history. But it is equally true that experience and training can bring forth and sharpen latent leadership ability. Experience puts confidence in a man. On-the-job training, where a good executive can help by giving praise and constructive criticism in a proper climate, is also helpful. It is the duty of management to provide the kind of climate in which leadership can be developed.

Q. What else would you prescribe for the man whose ambition is to be a manager?

A. It is very helpful if, at a certain point, a man can take one of the many management development courses now available. Such a course can broaden his concepts of management and give him a better acquaintance with the responsibilities of policy-making. It also gives a man an opportunity to get away from his job — a chance to evaluate the role of management in American business and industry and a chance to evaluate himself. It is sometimes hard to gain insights of this kind from our day-to-day work.

Q. How does Humble develop its management?

A. We have an executive development program. The entire managerial organization is reviewed each year. Each department is responsible for the executive development of its own personnel.

Job rotation is one method used to develop the individual. We also have a number of in-company management training courses. In addition, we carefully select each year a number of employees for enrollment in the executive development programs of various universities.

To aid employees in their self-development, the company makes available a wide variety of information about the company, the petroleum industry, and business in general.

However, with all our planning and our programs for executive development, we have found no substitute for on-the-job training. A company can offer a man opportunities for growth and training but in the final analysis his development must be self development.

Q. Will management have different responsibilities in the future?

A. Management will have the same responsibilities, but they are likely to be much more complex. Since there is only so much one man can handle efficiently, there may be certain areas where a greater division of responsibilities will be necessary.

For example, an accelerated trend toward decentralization might call for horizontal rather than vertical management. In certain areas, more authority might have to be given to staff people, enabling them to assume some of the responsibilities of management without, at the same time, burdening them with the administrative detail and personnel duties that some staff men object to.

Q. Do you have a favored definition of Staff versus Line? We find a lot of confusion on this.

A. In an effective organization, because they work so close together, it is sometimes difficult to see where staff and line separate. A line organization assigns definite responsibilities and authority for the conduct of the business. Staff organization assists them in specialized fields. Highly competent staff people sometimes exert an influence that is commensurate with authority.

Q. How will automation affect the oil and gas industries?

A. It will demand more highly skilled workers. At the same time, it should make available more information, and do this faster and with greater accuracy, so decisions should therefore be better.

Q. Will this tend to make the management even more important to business?

A. It may, but I think a manager should always keep his perspective. The world is going on whether he comes to work or not. And the business will probably go on, too, since someone else will be there to assume his responsibilities and duties.

Q. Do you think management can measure up to this demand of high competency and yet keep this philosophical spirit?

A. Who knows? As the Old Timer said, "It was a whole lot easier to make a decision when we didn't have all this information."

But one final thought: Quite often, I think, top managers forget that their creative days — in the strict sense of the phrase — are over. More and more, their job has become one of selecting between ideas and suggestions given them by others. They must accept ideas from those in the organization and they must encourage their people to keep the ideas flowing. Management's main energies should be concentrated on organizing and policy-making, on leading the company in a competitive economy. ★ ★ ★

RAY H. HORTON *was made president and head of the Board of Management of the Humble Division in the reorganization of Humble Oil and Refining in 1959. Although he himself says professional people do not always make good managers, he is proof that they can. He received his BS degree in geology from University of Oklahoma in 1930. He'd already had considerable oilfield experience working in summers for drilling contractors when he was in high school at Ardmore, Oklahoma. The new graduate joined Humble and worked on various field jobs in the production department. He became safety engineer and in 1935 manager of regional industrial relations for the East Texas division.*

Mr. Horton was transferred to Houston in 1945 as policy coordinator for production. Then followed these promotions: industrial relations manager, company director, vice president (employee relations, purchasing, and general services) and finally his present post as Humble Division president.

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Wilson J. Bentley

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Inventory of parts and supplies in production and drilling districts have been reduced by approximately 25 percent.

Assignment of duties and responsibilities of personnel in production, exploration, drilling, and refining have been made and communicated to the individuals. Number of vehicles and drivers in the field was reduced by approximately 15 percent with no harm to operations.

Refinery maintenance standards for planning purposes and for performance evaluation were established.

Personnel and equipment for foreign geophysical work were reduced by 20 percent with no effect on productivity.

A technical and executive development program was staffed and is operating well.

Administrative and personnel procedures have been streamlined.

A modern job evaluation plan for hourly and salaried employees has been set up and implemented for some 10,000 employees.

Is there an oil company executive who wouldn't like to read such a report about his own company? These are the accomplishments of the Tecnica Direzionale departments (management engineering) of ENI.

The history and activities of the interesting (and sometimes controversial) Italian oil company, Ente Nazionale Idrocarburi (ENI) have attracted much attention in international petroleum circles. Although a government-owned company, it operates in many areas outside Italy. The company's intelligent and dynamic president, Ing. Enrico Mattei, has set an aggressive course. The latest innovation in organization of the huge complex is the industrial engineering (or as ENI calls it — management engineering) function, which has been active in the organization since early 1958.

Studies, analyses and recommendations of the management engineering department account for many modern and efficient practices which ENI has adopted. With its excellent results this departmental function commands the interest of oil company executives everywhere.

Let me tell you first how it was established. During 1957 and 1958, the U. S. management consulting firm of Booz, Allen and Hamilton was employed to study the organization structure of the ENI group, which comprises many companies. A number of ENI employees worked closely with the consulting firm on the study and helped make recommendations for reorganization.

Ing. Enrico Mattei, aggressive president of ENI, sits at right listening to Tecnica Direzionale Director T. C. Quakenboss addressing a graduating class of the Executive Development Course.

One new function recommended was entitled Tecnica Direzionale, or management engineering, as the consulting firm called it. This function was to have as its objective: "To develop progressive management improvement and operating cost reduction programs and to cooperate with line and staff management in their application."

The function would have staff departmental status and could be installed in any of the member companies of ENI for which it was deemed advisable. Coordination of the departments in the various companies was to be done by ENI Tecnica Direzionale. This department would be headed by a director who would:

Aid top management of ENI in organization planning.

Coordinate the activities of all management engineering departments.

Direct projects involving more than one operating company.

Train management engineers.

Head up a program of executive and technical development.

The proposal to initiate management engineering was accepted and the job of obtaining staff and implementing departments was begun. At the moment, ENI companies with the largest number of employees all have management engineering departments in active operation. They include:

SNAM—pipeline, shipping, etc.

AGIP—distribution company

Agip Mineraria—exploration, drilling and producing company

Nuova Pignone—industrial manufacturing.

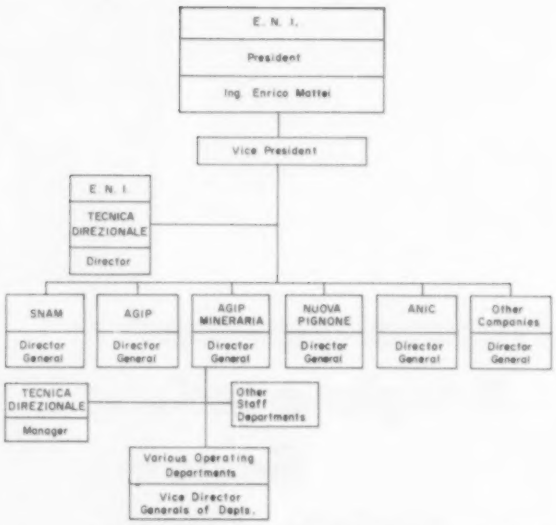
ANIC—chemical company

Managers of each of the departments are Italian and are all well qualified. They either have good engineering educational backgrounds or good management engineering experience or both. Many have advanced degrees, some from U. S. universities. They have staffed their departments with experienced people and then have continued to train them and others.

A department will vary from 5 to 30 management engineers, depending upon the size of the company. A skeleton organization chart showing the relative positions of these departments is shown in Fig 1.

Director of the coordinating department for ENI Management Engineering is an American, T. C. Quackenboss. He is a mechanical engineering graduate of Northwestern University finishing in the middle 1930's. Quackenboss has held several top operating positions in the United States in addition to being a consultant with one of the major management consulting companies. He maintains an office in ENI's 14-story building in San Donato Milanese (outside of Milan) and also his department office in the company's Rome offices.

ENI's interests and locations are so widely scattered that Quackenboss is continually on the go. For him, a 14-hour working day is the rule rather than the exception.



Typical organizational relationship of management engineering departments. This provides also a picture of the ENI set-up, which can be puzzling to outsiders.

After this you'll want to know: Have these departments obtained any significant results? This author had the opportunity to observe the efforts and aid in the activities of Quackenboss' coordinating department and also the management engineering department of Agip Mineraria. A series of three articles which I wrote for THE PETROLEUM ENGINEER in 1954 brought the attention of company personnel to me. These articles were entitled, "Improving Rotary Rig Operations" and resulted from consulting done with Eason Oil Company of Oklahoma City.

Study Drilling Efficiency

Ing. Egidio Egidi, vice director general of the drilling and producing department of Agip Mineraria and Ing. Dante Cavalli, manager of the management engineering department, were having excellent results using the content of these articles in reference to their 30-32 drilling rigs. They decided to obtain additional help by asking me to spend June, July and August 1959, with their field and home office personnel.

As indicated, one of the principal areas of interest was the time it takes to tear down and erect a portable drilling rig. They have made extensive and detailed studies of this important area of operation. Analyzing the studies helped field supervision to improve advanced planning and to make better use of drilling crews, trucks and cranes. "Waiting time"—whether it was that of personnel or machines—was noted, analyzed and recommendations made or standard procedures established. Toolpushers were aided in really "seeing" their operation with a more discerning eye. Increases in efficiency are conservatively estimated at 20 per cent for this activity.

Utilization of manpower while "drilling ahead" was also studied. Results were not quite so startling, but do contribute to better overall operating efficiency.

Study of production district offices, yards and maintenance activities brought some surprising summaries and recommendations. Here again, the management engineer (1) crystallizes the objective; (2) observes the present operations; in discussion with line management (3) decides

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THE AUTHOR

WILSON J. BENTLEY, *head of School of Industrial Engineering and Management at Oklahoma State University, received a degree in Industrial Engineering at OSU in 1939. He spent a year in electrical construction work, then nearly six years as an army engineering officer in the Combat Engineers and as Advisor on American Engineer Materials to the chief of French Army Engineers. Following WW II he was employed three years as an industrial engineer by Wilson & Company, meat packers. He then spent one year as assistant professor in the School of Industrial Engineering & Management at OSU and another year with Deep Rock Oil Corporation as refinery industrial engineer. Bentley returned to the staff of Oklahoma State University and in 1955 became a professor of Industrial Engineering and Management before taking his present post. He serves in a consulting capacity to numerous industries in the field of management, organization, methods study and job evaluation.*

Professor Bentley has been widely published on management and engineering subjects. He takes an active part in professional engineering societies.

what activities are necessary; (4) what procedures should be changed, and (5) agrees upon a plan for implementation without "upsetting the apple cart."

There are *some* instances in which more people or more (or different) equipment was found necessary. *The management engineers' philosophy is to look for means to maintain (or improve) quality and obtain maximum productivity at the lowest cost.* To attain this goal, he sometimes finds it necessary to add instead of reduce personnel.

Just a thorough study of the equipment needed for foreign geophysical exploratory work resulted in significant savings in supply expenses.

Manager's Job

The manager of the management engineering department assists his company president, or "Director General," in company-wide organization planning. He maintains organization charts, as well as an organization manual on a current basis. This involves reviewing proposed new positions, organizational changes or changes in responsibilities. He directs the study of manpower requirements and works closely with the personnel director in determining personnel needed for the various functions of the business.

The manager also reviews plans for anticipated capital expenditures and makes an economic evaluation with consequent recommendations. He constantly studies the reporting structure and recommends changes to assure adequate control of performance by management personnel.

This manager is also responsible for the installation of job evaluation and classification programs and then assists the personnel department in their administration. As has been indicated previously, he is responsible for studying all work methods in his company, set up standards wherever possible, and recommend changes to improve efficiency, quality, or productivity—or all three.

He has a staff of specialists and office assistants to whom he can delegate the duties described, but only he is held responsible by his director general. ENI management personnel, as a whole, are quite sophisticated in their knowledge of management and organization. Their use of the line and staff organization is quite similar to our better companies in the U. S.

The functions and activities are not thought of as a "police" action at all, nor have they been tainted with the "efficiency expert" role. Rather, they are considered to be an aid to better and more productive management of the resources of the company. Many activities have to be studied and analyzed once only. The manager of the activity takes advantage of this staff aid and applies it, himself, the next time the occasion arises. So, in many ways, the function of the Tecnica Direzionale (Management Engineering Department) is one of observation, analysis, recommendation, and *teaching or education* of the managing personnel.

Development and Training

Part of this author's work was educational and carried on under the auspices of ENI's "Istituto Direzionale e Tecnico" or Technical Institute. Approximately 25 young management engineers, petroleum engineers, and field supervisors were given classroom and field training in the application of methods improvement to any phase of work. Through this educational experience, they were able to "see" their operations in a more objective light and numerous improvements have taken place as a result.

The "Istituto," as it is familiarly called, is directed by Quackenboss through a Dean who is the operational head. There is a regular staff of well qualified professors who conduct the classes in courses varying in length from a few days to 10 months. The regular staff is predominately Italian, although currently, it includes three Americans: Dr. Morton Backer of NYU is the Dean; Dr. Burnard Sord, of the University of Texas, is teaching business policies and related courses; and Professor John Reidel is teaching petroleum refining. Dr. Dennis Crites, of the University of Oklahoma, will join the staff and head the marketing classes. There is also a five-week executive development course which runs continuously. The "Istituto" naturally calls upon experts in the company and outside the company for specific assignments.

Quackenboss obtains professional men from other countries for special courses. These have included: E. Trent Woods, now of Varel in Dallas; Dr. Adam Abruzzi of Stevens Institute; Norman Clark of Norman Clark Engineering Petroleum Consultants in Dallas; Dr. Ralph J. Neilsen, head of Petroleum Production at Pennsylvania State University; and this writer.

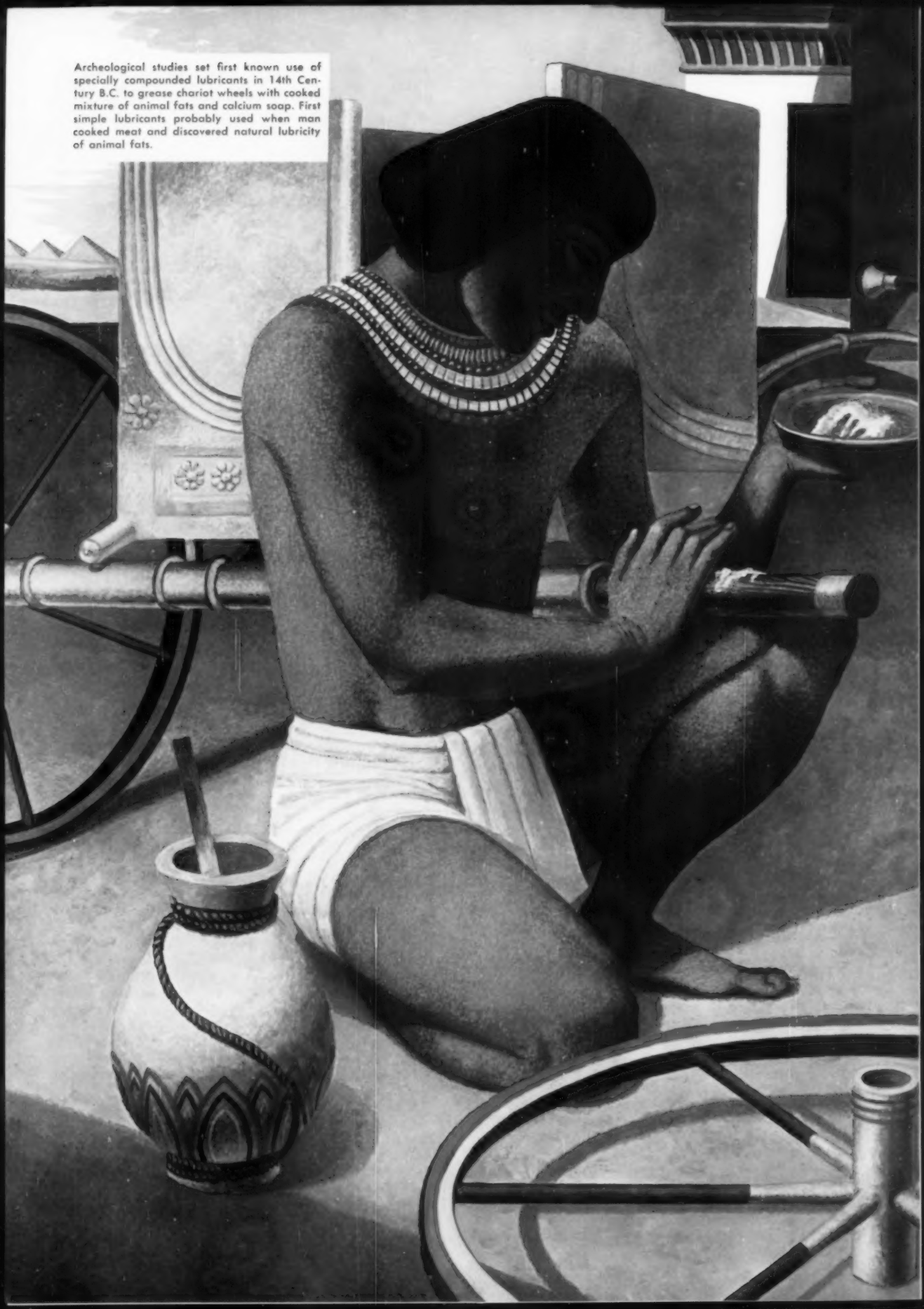
Professor Bentley and interpreter, Ing. Romano, lecture to a group on job evaluation. This is part of the management development training.

The activities of the "Istituto" are significant in size and varied in scope. Yet, the educational aspect ties in closely with the objectives of the management engineering objectives.

Members of each of the companies in the ENI group participate in the educational program described. Companies of the group which do not have management engineering departments also call on the ENI coordinative department for consultative aid in certain cases. This aid may be performed by that department or it may be delegated to the management engineering department in SNAM, ANIC or one of the others.

The energetic management of ENI is trying to pull the company up by "its own bootstraps"—in a hurry. They want to skip 20 years of development that U. S. companies have gone through. They want to jump from a comparatively unsophisticated and uneconomic company to a sophisticated, well balanced, technically and organizationally) and economic operation. The management engineering activities are taking a significant part in aiding these young executives in attaining this goal.

ENI President Mattei and his top management are well aware of the role that the Tecnica Direzionali is taking in helping make the company a truly modern competitive organization. It should be added that these management engineering departments hold a unique place in Western Europe industry in that few, if any, contain a group so advanced and in so many activities. ★ ★ ★


Archeological studies set first known use of specially compounded lubricants in 14th Century B.C. to grease chariot wheels with cooked mixture of animal fats and calcium soap. First simple lubricants probably used when man cooked meat and discovered natural lubricity of animal fats.

he greased the wheel of progress

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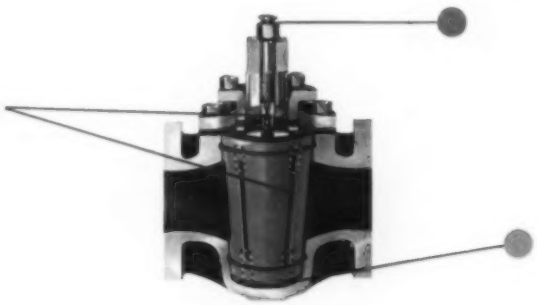

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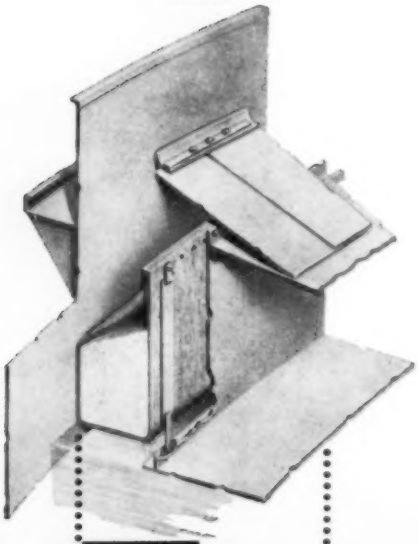

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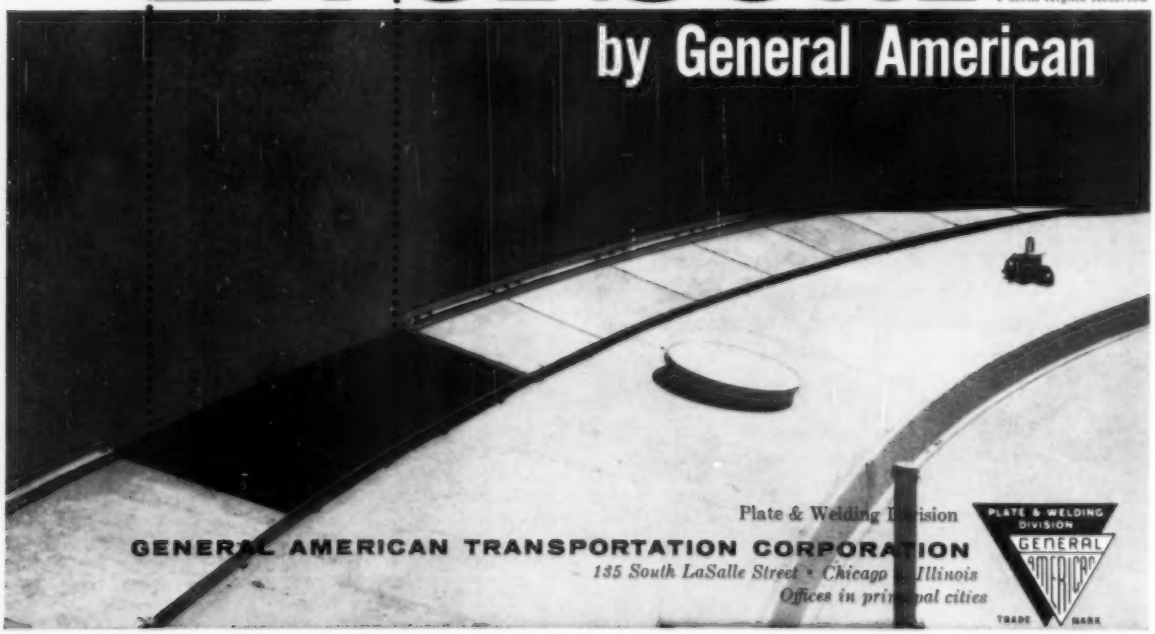

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Watch Your Finances

R. LEE OWENS

"You're worth what you saved, not the million you made."
— JOHN BOYLE O'REILLY

SINCE MAN FIRST began exchanging clam shells for new bearskins, there have been certain individuals who showed a talent for managing money. Some have passed on great fortunes to their descendants. But the obvious fact is that most of us do not fall in the class of either organizers of great fortunes or managers of inherited wealth. The majority of people in our present society have, at least by our standards of living, moderate amounts of money to deal with at any one time. It is to this large segment of moderate-income people that this article is directed.

Consider first the young man, perhaps newly married, who is ready to start his business career. Few companies would immediately consider him for an important management position. Yet as the head of a new household he is immediately in a position of managing the finances of the family. How he reacts to this challenge is often a clear indicator of how he will do in business management on down the road.

In earlier years, he and his bride, living in separate households, were surrounded by the accumulations of their parents. In the parents' homes were appliances, furniture, one or even two cars, and whatever other possessions were important to the parents. Abruptly, the young couple find themselves without many of the conveniences of their earlier years and with an income inadequate to provide all these things at once. Their limited supply of clam shells won't buy all the bearskins they want. This represents the new family's first financial challenge since they set out on their own. How will they respond?

None of us has reached this point without a little prior experience. From parents, school, and church we have been given many elemental lessons of thrift, the value of the wise use of money. From our first piggy bank, we have experienced the delicious rewards of the "large" purchase with saved pennies. Slogans and mottos praising thrift and saving are always before us.

Your income is limited.

BUYING ON TIME

But how about credit cards and handy-cash, and easy terms, and all the other inducements to buy without money? They are more a part of contemporary life than of a decade ago. No down payment and 30 years to repay are innovations of fairly recent years. In the management of personal finances, it is at this point that the trial by fire begins.

There are, of course, families that refuse to buy anything on time. But the majority are certain to have several charge accounts in short order. The good management of these first accounts is essential to the success of the family.

On paper, that last sentence reads like an obvious cliche. And yet uncounted families are right now going through difficult times because of the mis-management of this first credit. The most talented of men, plagued by financial problems at home, find their energies drained and sometimes their very chances of advancement blocked by their preoccupation with money worries.

Experienced managers of money set down one cardinal rule for personal finances: seek help *before* your payments are due. In other words, anticipate the problem as far in advance as possible.

R. Lee Owens *is manager of the savings department of First National Bank in Dallas, a veteran of more than 40 years in banking.*

Shortly after graduation from the University of Dallas in 1916, he joined a predecessor bank of First National. Since 1917, he has gained banking experience in the bookkeeping, tellers, installment finance and service departments as well as in the savings department.

Named an officer of First National in 1950, Mr. Owens served as a loan officer in the installment finance department and in the service area. He was named in charge of the savings department in 1955.

It isn't always easy
to anticipate the problem.

Most financial difficulties involving personal finances are not of instantaneous origin. They build up over a period of time until the wall of real or imagined trouble is so high that the person in difficulty can't see over. The first and probably normal reaction of a person in financial trouble is one of shame and embarrassment. His inclination is to keep it a secret and hope for some miracle. Such hope is rarely rewarded.

Some seek an answer to their difficulties in the offices of so-called "loan sharks." Many have found their problems compounded many times by such ready succor.

Where, then, is there good advice and counsel?

HOW TO TACKLE DEBT

Perhaps we could draw a parallel with the man who needs legal advice. He can talk to his neighbor over the back fence and most likely get an opinion. But if he wants more than a "guardhouse lawyer's" advice, he will seek competent legal help. Similarly, friends may have much free advice to offer in matters of financial problems. But again, it is nearly always the man who makes it a business to solve such problems that can offer the most valid solution to the problem.

Realizing that a man with financial troubles is often embarrassed, modern banks have done away with the old-fashioned "mourner's bench" in the lobby for those seeking loans. Now, separate loan departments are set up, and the individual can be certain that all those around him have similar problems.

Well meaning friends are
not always best counsellors.

The 1960-model loan officer is a man of considerable sympathy and understanding. He is skilled in dealing with financial problems large and small. This officer is no bubbling fountain of ready cash, but in the great majority of cases he is qualified to analyze the situation and work out a solution to what may have seemed an insoluble problem.

He will probably stress that the first step toward clearing up the situation is an iron will and determination to get right with your creditors. He will suggest that you go to each and explain your difficulty and work out some longer-term method of repayment. Creditors are less likely to press if they know you are paying something each month and trying to erase the bad debt. This determination to improve your debt picture must come from you. To take the alternative and try to run away from a bad debt is as pointless as trying to lose your shadow on a sunny day.

LEARN TO USE BANK SERVICES

Many people think of banks only as a place to deposit money and to make loans. Actually, bank services are as broad as the needs of its customers.

As a case in point, a Dallas acquaintance recently went to a Midwestern city to serve as executrix for the estate of a relative. Unknown in the city, she was refused access to the deceased's personal belongings. Pressure was applied to get her to sign away her legal rights. Frustrated and confused, she telephoned bank friends in Dallas for advice. Banks, you know, have working relationships with other banks in all parts of the nation. Her Dallas contacts were able to introduce her to qualified advisers in the Midwestern city. They in turn recommended an attorney skilled in handling such problems. And in a matter of hours, her difficulties were solved.

Costly? Actually, her costs were far less than if she had yielded to the pressure and signed the first papers thrust in front of her.

The purpose of the illustration is far deeper than just to show that banks can be helpful in difficult situations. To be known at the bank of your choice, to have a favorable credit reputation, and to be recognized as one who handles his personal finances properly is a valuable recommendation both in your home community and outside it.

BEST WAY TO SAVE MONEY

With the cost of living at or near all-time records, saving money today is not easy. The truth is, saving money never has been easy. It is one of the most difficult disciplines to establish and nourish.

"Well," some would say, "there just isn't anything left over after I've taken care of our family's needs."

That's true. And sad to say that will always be true for the families who approach the savings problem from the tag end rather than the front end.

If you want to save, set up a plan with a reasonable goal and have the savings money deducted before you ever cash your paycheck. Pay yourself first, rather than out of any leftover funds.

How much money would the average family have on hand to pay yearly income taxes if deductions were not made in advance? Whatever you think of the tax rate, you would probably concede that the government is making certain it gets paid first. Apply the same technique to develop a savings account for yourself.

From personal experience, I know of many families who have grown to a point of financial independence by this means. One young man whom I've gotten to know well

Here's the highballing crew that teamed up to pull and stack 6,000 feet of drill pipe in little more than one hour. Superintendent H. T. Love, and crewmen C. R. Williams, R. P. Williams and J. S. Light. Another member of the team—the International V-8 engine—is in the background.

6,000 feet pulled and stacked in 65 minutes with International V-8 engine

The Poole Well Service Co. of Midland, Texas is replacing 2½-inch tubing with 3½-inch for a sand fracturing operation on Humble's T & L lease. Sole power on their Wilson self-propelled servicing rig is an International UV-549 V-8 engine. With this dependable power the normal 4-man crew recently pulled and stacked 6,000 feet of 2⅞-inch drill stem in one hour and five minutes—an average of two stands per minute!

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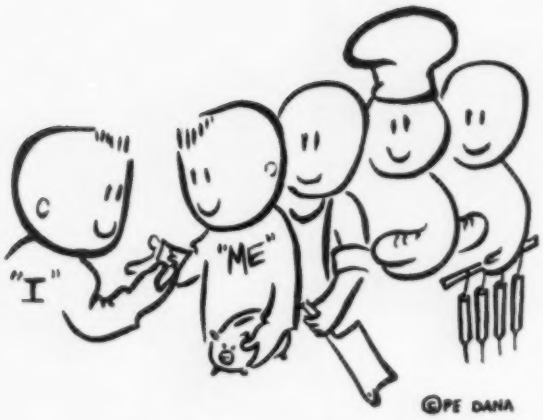


Who works for you hardest should be paid first.

started saving when his total weekly salary was $13. With every paycheck, he paid himself first. He never rose to be president of the company or even to the point of being wealthy. But today, his savings account, still intact, has grown to a total of more than $11,000.

No doubt there were many wants along the line that he could have satisfied with that money. But after the savings habit was part of his routine, he became more interested in saving that small weekly portion than in spending it. He is not a miser. His family is comfortably fixed. And just knowing that he could buy what he wanted has made him want even more to save.

KEEP IT SAFE

If you agree that the saving of money is difficult but not impossible, then you may also agree that hard-saved dollars should be safely kept. People's ideas of safety for their money range from old shoe boxes to federally insured savings accounts. As a banker, I would say you should demand three things of your savings dollars: safety, availability, and growth. How you achieve these demands, that is, what form of savings institution you select, may depend on your past experiences and your present attitudes. The slogan, "Investigate Before You Invest," applies equally well to the selection of a savings institution.

Rather than recommend textbooks on money management, I would propose that you give your attention to daily newspapers and weekly or monthly publications that deal with finance. In these you will get a current picture of how money is successfully handled by others. Granted, this practical type of education leaves something to chance. But your personal financial problems may find their solutions in the current problems and answers of others.

Your savings dollars need three things.

BRING THE CHILDREN INTO THE FIRM

This final suggestion: bring your children into your financial counsels. They deserve a clear picture of your attitudes toward saving, borrowing and paying bills.

At first, they may have little to contribute, but if you set the pace of calm dealing with the family's problems, they in turn will have more respect for the value of their allowances and the part they play in the family. As we said in the beginning of this article, you may not leave a great fortune behind you, but your legacy of intelligent dealing with money problems can make up an estate of great value.

Give Yourself a Quiz

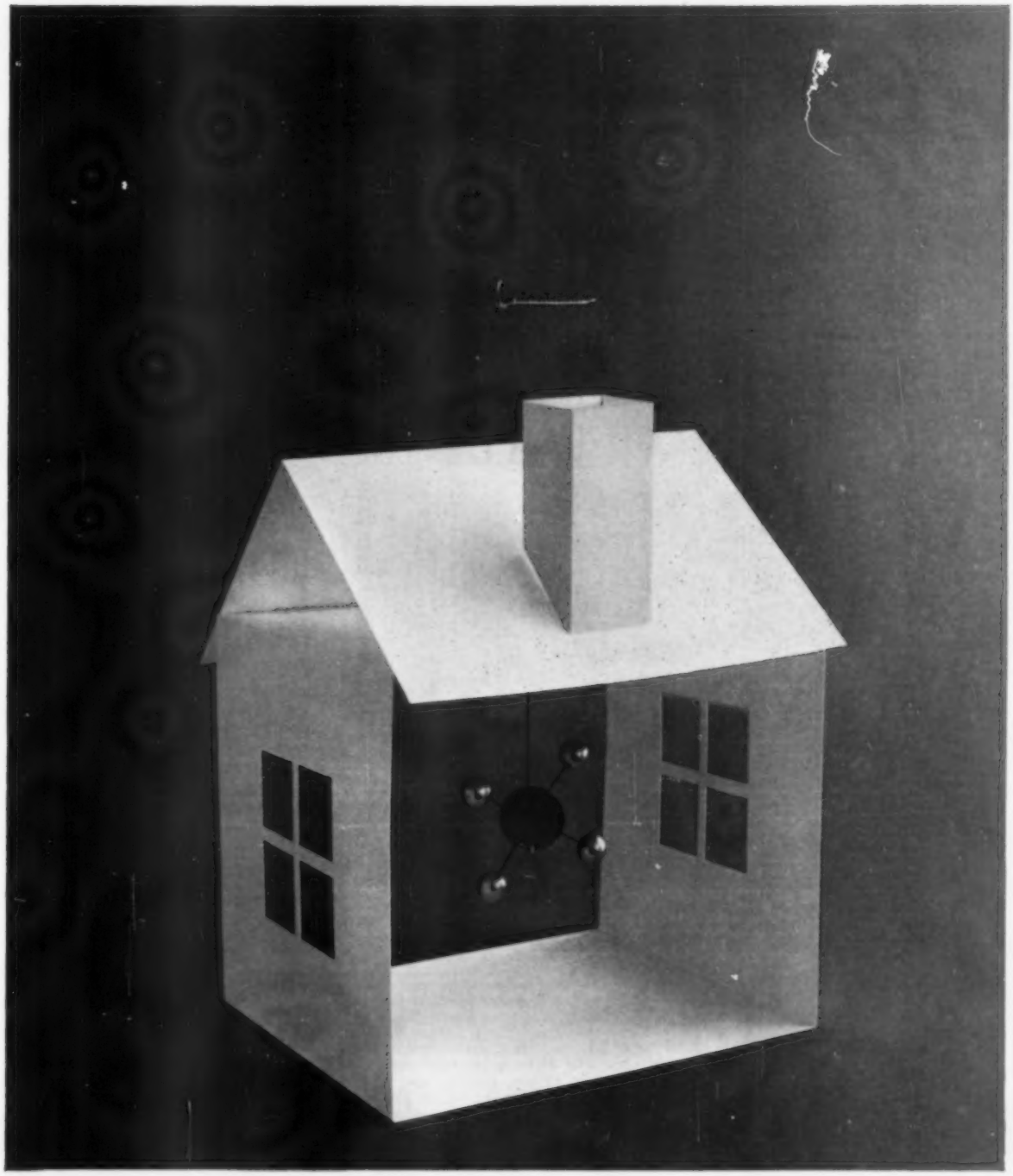
1. Do I make every effort to maintain a good credit rating?
2. Have I anticipated what moves to make should a financial crisis arise in my own family?
3. Are family financial problems discussed reasonably, or is more heat than light usually generated?
4. When they are able to understand, do we bring our children into family discussions of saving and spending?
5. Are we developing our children's attitudes and habits so they will have a sound basis for dealing with money problems in later years?
6. Have I made the necessary moves to establish my identity with officers where I bank?
7. Do I know what I'm getting for my savings dollar?

Bibliography, of Sorts

As for reading material to help you with family finances, there are, of course, many books available on the subject. Some devise formulas for allocating your paycheck to various family expenses. All, however, lack one essential ingredient: Intimate knowledge of your own family . . . how you live, what you consider important, what you will sacrifice for. It is not a mistake to apply general percentages to allocation of funds; however, only you and your family, working as a unit, can determine how those percentages should be modified to answer your own financial questions.

More pertinent for most families is the news contained in daily, weekly, and monthly publications dealing with financial information. My own experience has been most favorable with such daily papers as *The Wall Street Journal*.

In the weekly newspaper field, such publications as *Barrons* and *Financial and Commercial Chronicle* provide generous amounts of information on dealings in the financial area. *Financial World*, a weekly magazine, is also excellent for thumbnail sketches of individual companies, groups of companies, and legislation affecting American business. General news magazines, such as *U. S. News and World Report*, are most valuable in giving you a broad picture of the economy and changes that might affect your pocketbook.



"Plastics derived from oil someday will find important structural uses, in buildings and houses. Some scientists feel that crude oil components might be converted into foodstuffs. Imagine what could happen if the research departments of all companies made strong and sustained efforts to find *new* uses for oil!" – M. J. Rathbone, President

ESSO

Standard Oil Company (New Jersey)

Check Those References

THE COMPANY that fails to check references adequately on a candidate for an executive position stands a 50 percent chance of hiring the wrong man, Rawle Deland, partner, Thorndike Deland Associates, declared.

Reference-checking is more important than ever, Deland points out, particularly when executives are being recruited to fill responsible positions. Not only can a reference-check spot those who falsify their records or are concealing bad points or hidden faults but it also has a positive side: Knowing what a man has actually done is a great help in assessing his capabilities for another job.

Although some reference-givers tend to be too damning, Mr. Deland observes, equally dangerous are the well-intentioned reference-givers who are likely to be dishonest in a positive way — by painting too bright a picture of the candidate. Stressing the importance of knowing the reference-giver as thoroughly as the man who is being checked, Mr. Deland sketches four common types of reference-givers:

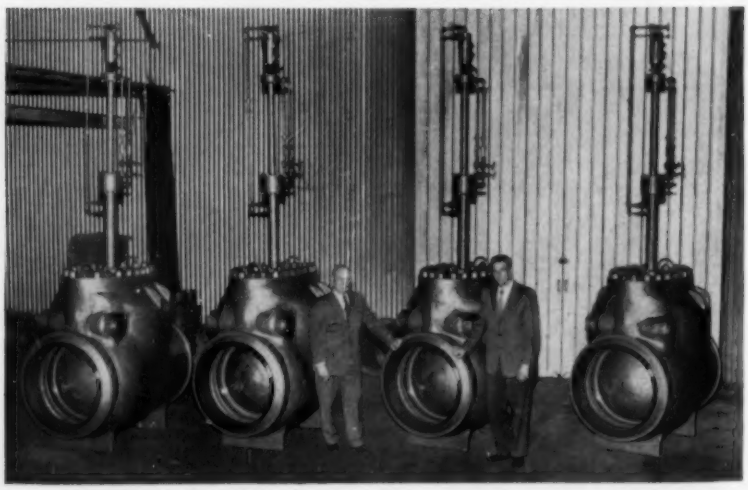
1. *The legal eagle — who once was sued or threatened by a former employee about whom he gave an honest opinion and who is now so gun-shy he'll never tell the truth.*
2. *The hatchet man — who is quick to stress faults.*
3. *The unforgiving one — who thinks that any executive who ever left his firm is automatically no good.*
4. *The bag of wind — who is full of meaningless words.*

Although it's been said, Mr. Deland notes, that salaries are one thing a man can lie about and still go to Heaven, a professional executive searcher can usually estimate an executive's salary within 10 percent if he knows the company, the industry, the job, and the man's length of service.

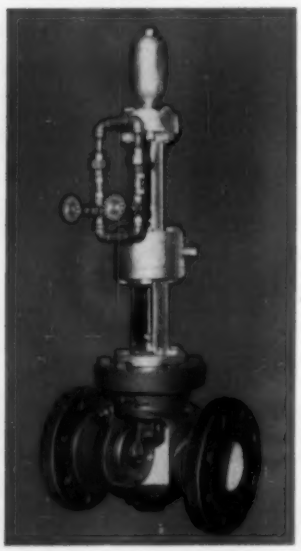
"A well-conducted reference check," according to Mr. Deland, "stands a very good chance of turning up all the information necessary to make a sound decision. The philanderer who thinks he'll never be seen in a little bistro in New York is relatively safe compared with the job candidate who tries to fly under false colors in getting a new job."

Excerpts From Management Review

AT LAST...
SLAM ELIMINATED!



Every major high pressure gas line under construction today will utilize Frank Wheatley's new Slam-Minimizer Check Valve. Above: a partial order of 30" Slam-Minimizer Check Valves ready for shipment to the Transwestern Pipeline project.



High pressure gas line maintenance and replacement savings in thousands of dollars are now possible through the use of Frank Wheatley's new Slam-Minimizer Check Valve. When installed and adjusted the Slam-Minimizer completely eliminates clapper slam and flutter. A unique hydraulic system governs the upward and downward movement of a piston linked to the clapper. The result — a smooth, quiet opening and closing under the most drastic mainline pressure changes.

NEW! Now you can convert your present Frank Wheatley Check Valves with a Slam-Minimizer Adaptor Kit. Low cost and easy installation makes it completely practical.

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PUMPS & VALVES
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Complete details available upon your written request.

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TULSA, OKLAHOMA
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YOUR SUPPLY STORE SHOULD HAVE THEM!

Got a Minute

WHAT do you do with the time you save?

Al saves time skipping lunch and other meals. He spends it nursing an ulcer.

Gil saves time not going into detail instructing his employees. He spends it clearing up mistakes and filling out scrap records.

Jack saved time going 40 mph. in a 25 mph. zone. He's spending it in the penitentiary for manslaughter of a pedestrian.

Sam saves time taking happy pills to keep him going all hours. He spends it with his psychiatrist.

Marty saved time putting a penny in the fuse box, instead of going to the store for more fuses. He's spending it working on a second job, trying to replace his house which burned down.

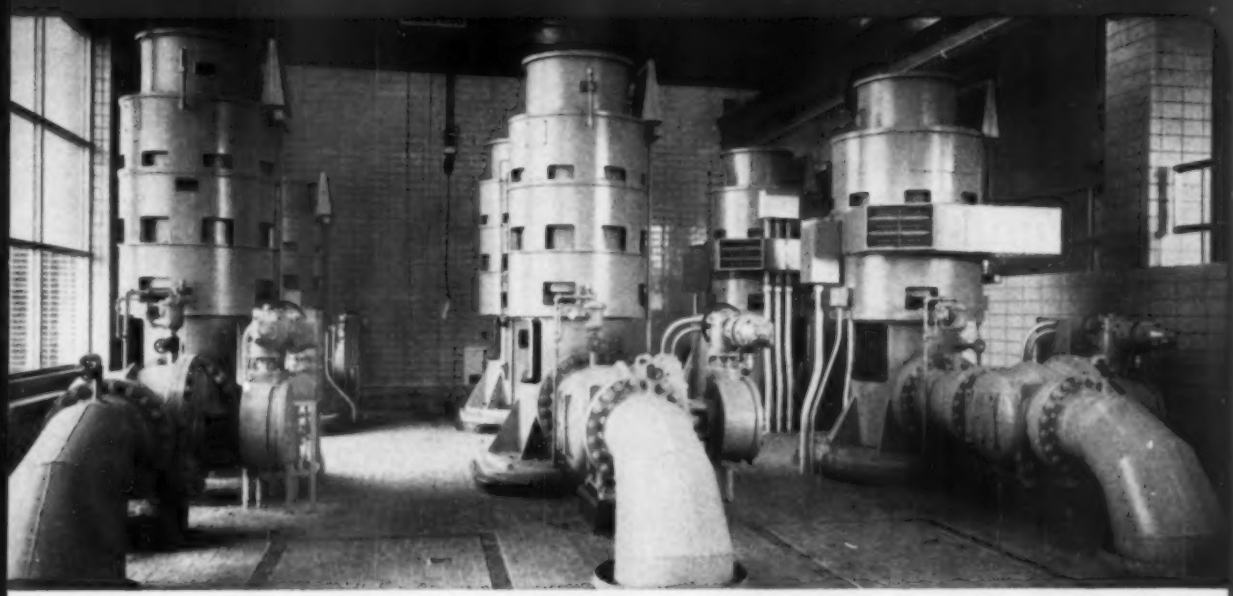
Marv saved minutes every day for 20 years racing home from work in his car. He spent it guzzling beer and eating pretzels—put on an extra 40 pounds of weight—had a heart attack at age 45.

Joe saved time not waiting for help to lift a heavy part. He spent it lying in bed with a slipped disc.

Frank saved time working instead of playing with the kids when they were young. He's spending it wondering what happened to the babies he once had.

So — why be so anxious to save a minute? You can't afford to save that way!

By Robert D. Gidel, Chief of the Division of Safety Standards and Services, Washington, D. C.



PLENTY OF WATER for Springfield-66 MILLION GPD Max.

Springfield, Ohio has a completely new, automatic water supply system by Layne. It guarantees 66 million gallons per day for their present and future needs—a job complete by Layne—and a completely satisfied customer. Field Tests exceeded the guaranteed pump efficiencies by 1% to 2% on all units. Consulting Engineers: Black and Veatch, Kansas City Missouri. Water Supply Contractors: The Layne Ohio Company, Columbus, Ohio. Do you need complete water service? Get it from Layne. Write for Bulletin 100.

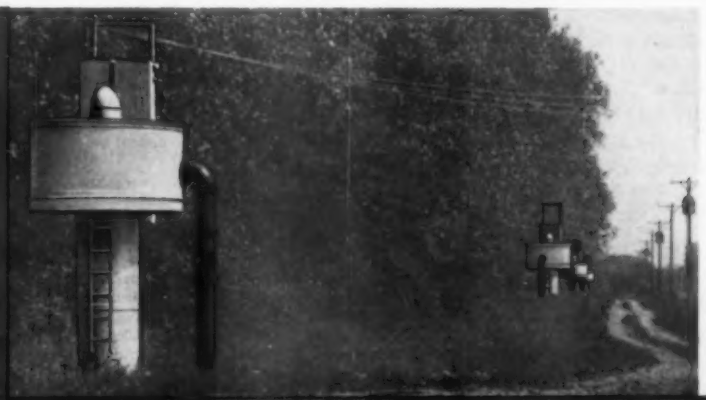
Specifications

RAW WATER—10 Layne Gravel Wall Wells with Layne 18-8 Stainless Steel shutter screen and 10 Layne deep well pumps. 2800 GPM — 65 ft. TDH, 75 hp—440 Volts— 1750 RPM, located in two banks pumping to the filter beds. Pumps were installed 15 feet above ground level for flood protection.

FILTERED WATER—Six Layne high service pumps boosting filtered water into distribution system. Five are 12 MGD-285 ft. TDH, 700 hp—4160 volts—1185 RPM. Two are variable speed units. The sixth Layne Pump is a 6 MGD-285 ft. TDH, 400 hp—4160 volts—1185 RPM. All pumps operate through the central control panel.

City of Springfield, Ohio

LAYNE OFFERS COMPLETE WATER SERVICE: Initial Surveys • explorations • recommendations • site selection foundation and soil-sampling • well drilling • well casing and screen • pump design, manufacture and installation construction of water systems • maintenance and service • chemical treatment of water wells • water treatment—all backed by Layne Research. *Layne services do not replace, but coordinate with the services of consulting, plant and city engineers.*



Layne SINCE 1882 — WORLD'S LARGEST WATER DEVELOPERS

LAYNE & BOWLER, INC., MEMPHIS
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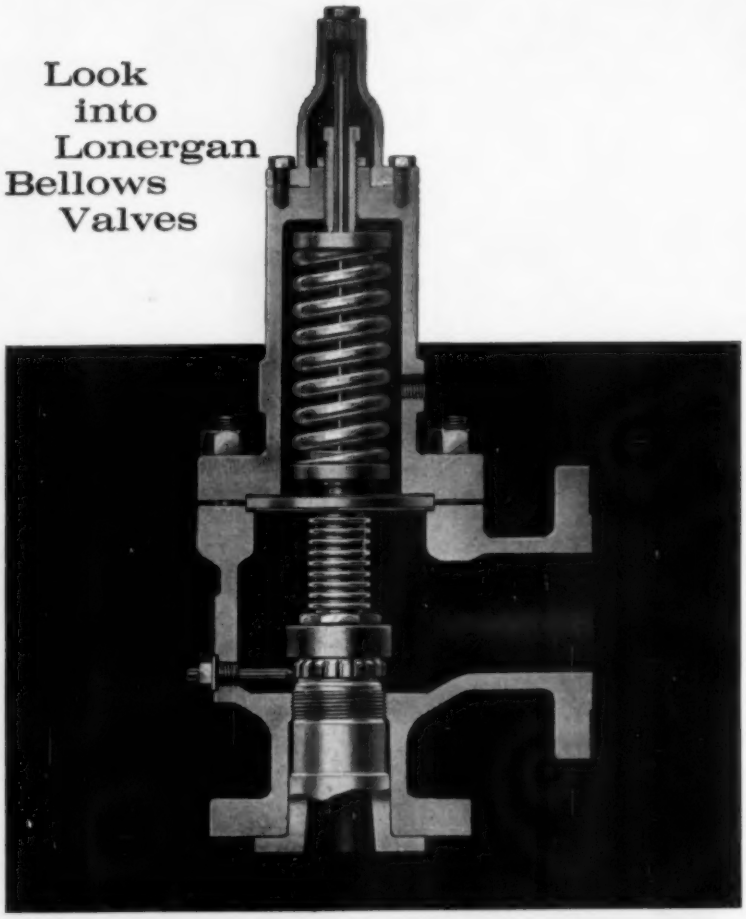
LAYNE ASSOCIATE COMPANIES THROUGHOUT THE WORLD
Sales Representatives in Major Cities

Look into Lonergan Bellows Valves



Seven exclusive features reduce maintenance costs; provide increased valve versatility.

Like all bellows valves, Lonergan valves are designed to keep corrosive or viscous fluids away from working parts. In addition, they provide a balancing action against a variable back pressure. The similarity between Lonergan and any other bellows valve ends there. *Only Lonergan valves provide:*

1. *Saf-T-Alarm to warn of bellows failure. Alarm may be remotely located. (Optional at extra cost.)

2. Complete interchangeability with conventional valves of the same series.

3. Versatile cap arrangement. Bolted cap is standard and is interchangeable with a packed cap without taking the valve off the line or out of service. Gag facility is included.

4. *Simplified nozzle replacement due to an exclusive knockout feature. (Optional.)

5. A Hydro model; a patented, true, non-chattering liquid valve. Elimination of chatter ends bellows failure due to excessive flexing.

6. Reserve seating surface obtained from a built-in spare disc.

7. PVC trim, where pressure-temperature conditions permit.

These seven features mean economy for Lonergan valve users—in first cost; in operation; in maintenance. If your plant uses bellows valves, then it will pay you to investigate Lonergan. Series DB bellows valves are described in a new bulletin. Series D valves, available without the bellows, are also described. Write for your copy today.

**Patent Pending*

Lonergan

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Meetings . . .

Aug. 15-17 — American Society of Mechanical Engineers — American Institute of Chemical Engineers, heat transfer conference and exhibit, Statler Hilton Hotel, Buffalo, N. Y.

Aug. 29-31 — Appalachian Gas Measurement Short Course, 20th Annual, West Virginia University, Morgantown, West Virginia.

Sept. 7-9 — Automatic Control Conference, 1st joint, sponsored by ISA, AIChE, AIEE, ASME, IRE, Massachusetts Institute of Technology, Cambridge, Mass.

Sept. 8-9 — Mid-Continent Oil & Gas Assn., membership meeting, Louisiana-Arkansas Division, Roosevelt Hotel New Orleans, La.

Sept. 11-13 — New Mexico Petroleum Industries Committee, annual convention, Western Skies Hotel, Albuquerque, N. M.

Sept. 11-16 — American Chemical Society, national meeting, New York City.

Sept. 12-14 — Asphalt Institute, management committee meeting, Point Clear, Ala.

Sept. 14-15 — Western Petroleum Refiners Assn., Rocky Mountain regional technical-industrial relations meeting, Henning Hotel, Casper, Wyo.

Sept. 14-16 — National Petroleum Assn., annual meeting, Traymore Hotel, Atlantic City, N. J.

Sept. 15 — Natural Gasoline Assn. of America, Rocky Mountain regional meeting, Palliser Hotel, Calgary, Alberta, Canada.

Sept. 18-21 — American Society of Mechanical Engineers, petroleum mechanical engineering conference, Jung Hotel, New Orleans, La.

Sept. 19-21 — Texas Mid-Continent Oil & Gas Assn., annual meeting, San Antonio, Texas.

Sept. 20-21 — Illinois Oil Industry convention, St. Nicholas Hotel, Springfield, Ill.

Sept. 20-21 — Water Lift Institute, Court House, Liberal, Kans.

Sept. 20-21 — American Gas Assn., organization meetings, Hotel Cleveland, Cleveland, Ohio.

Sept. 23-24 — Assn. of Desk & Derrick Clubs, annual convention, Sheraton-Cadillac Hotel, Detroit, Mich.

Sept. 25-27 — American Assn. of Oilwell Drilling Contractors, annual meeting, Roosevelt Hotel, New Orleans, La.

Sept. 25-28 — American Institute of Electrical Engineers, petroleum industry committee, Hotel Skirvin, Oklahoma City, Okla.

Sept. 26-29 — American Welding Society, national fall meeting, Hotel Penn-Sheraton, Pittsburgh, Pa.

Sept. 26-30 — ISA, Instrument-Automation Conference and Exhibit and ISA's 15th annual meet, New York Coliseum, New York City.

Sept. 29-30 — Mid-Continent Oil & Gas Assn., Mississippi-Alabama division meeting, Grand Hotel, Point Clear, Ala.

Oct. 2-5 — Society of Petroleum Engineers of AIME, annual fall meeting, Denver, Colo.

Oct. 4-5 — Gas Measurement Institute, National Guard Armory, Liberal, Kansas.

Oct. 6-7 — National Assn. of Corrosion Engineers, annual Western region conference, Sheraton-Place Hotel, San Francisco, Calif.

Oct. 6-8 — National Assn. of Corrosion Engineers, Southeast region conference, Dinkler-Plaza Hotel, Atlanta, Ga.

Oct. 10-12 — American Gas Assn., annual convention, Atlantic City, N. J.

Oct. 11-14 — National Assn. of Corrosion Engineers, Northeast region conference, Prichard Hotel, Huntington, W. Va.

Oct. 12-14 — Southwest Federation of Geological Societies, annual meeting, Abilene, Tex.

Oct. 13-14 — California Natural Gasoline Assn., annual fall meeting, Hotel Miramar, Santa Monica, Calif.

Oct. 17-19 — Production Drilling & Blasting Symposium, 10th annual, Colorado School of Mines, Golden, Colorado.

Laugh with Barney

Man criticizes woman for her extravagance, but she never wastes two dollars' worth of shotgun shells in order to get a 20-cent rabbit.

Nor uses 20 gallons of gasoline and pays $25 boat hire to get where the fish aren't.

Nor goes into a restaurant and buys a 25-cent meal and gives the waiter a 25-cent tip because he smiled at her.

* * *

Rastus' lawyer was informing him on the legal status of his matrimonial relationship and his chances for a divorce: "Mistuh Johnson, I has discovered I can get you yo' deevorce on the grounds that yo' marriage ain't legal on account of her father he had no license to carry a gun."

* * *

The gentleman sat down at the bar and ordered a martini. "Very dry," he insisted. "Twenty parts of gin to one part vermouth."

"All right, sir," said the bartender. "Shall I twist a bit of lemon peel over it?"

"My good man, when I want lemonade, I'll ask for it."

* * *

An old maid in a hotel complained that there was a naked man in a room just across the court from her window. The house detective answering the complaint said that since the man was visible only from the waist up, the old maid should not be offended. He said, "Lady, you don't see any more of that man's person than you would of a wrestler or boxer. You don't even know for sure that the man is entirely naked."

The old maid replied, "Well, if you don't think he's naked, just stand up on that bureau and look at him."

* * *

The owner of the house answered the bell to find a friend whom he hadn't seen for some time was at the door along with a large shaggy and rather muddy dog. Inviting them in, they sat in the living room and talked about old times. The wet dog, after sniffing around finally hopped on the couch and settled down for a nap much to the host's dismay.

Finally the guest rose to leave. "Aren't you forgetting your dog?" said the host.

"That's not my dog," said the guest. "I thought he was yours."

* * *

Among the machines developed by man's aversion to work is the political machine.

* * *

"So your father is a Southern planter?"
"Yes, he's an undertaker in Atlanta."

* * *

They laughed at me when I spoke to the waiter in Italian, but he came right back with some Scotch.

For Constant, Uninterrupted

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You'll Never Go Wrong with

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BALL BEARING MOTORS

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They are specifically designed to overcome the unusual conditions of Oil Field requirements, and there is a type and H.P. built to fit your exact needs. Unexcelled since they are . . .

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SEMI-ENCLOSED — normal or medium slip, 3 phase, 60 cycle. Has prelubricated ball bearings in semi-enclosed protected housing. 40 degree C rise. Built for continuous duty. **High Torque, low starting** current. Extra insulating coating throughout.

TOTALLY ENCLOSED — Fan cooled, normal or medium slip, 3 phase, 60 cycle. Has prelubricated ball bearings, totally enclosed FAN cooled 55 degrees C rise, for continuous duty. High Torque — low starting current. Extra insulating coating throughout.

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Manufactured by Valley Electric Corporation, St. Louis 8, Mo.

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AMERICAN-WESTCOTT A-88

ORIFICE METERS

Versatile American® Series A-88 mercury-type orifice meters meet the toughest flow measurement requirements – working pressures to 5,000 psi – interchangeable 10, 20, 50, 100 and 200-inch ranges. Recording meters may be equipped with 0-150° F. standard temperature element. Integrating meters integrate static and differential pressure, providing totalized flow indications. Telemetering equipped meters transmit integrated indications to remote locations.

- **Manometer body easily cleaned – does not affect calibration.**
- **Tamper-proof calibration – simple, positive adjustment of float lever arm length.**
- **Interchangeable ranges – no manifold piping changes.**
- **Teflon-packed stuffing box is pressure tight, nearly frictionless, never needs lubrication.**
- **Teflon-packed pulsation dampener externally adjustable under full line pressure.**
- **Check valves give positive shut-off for over-range protection.**

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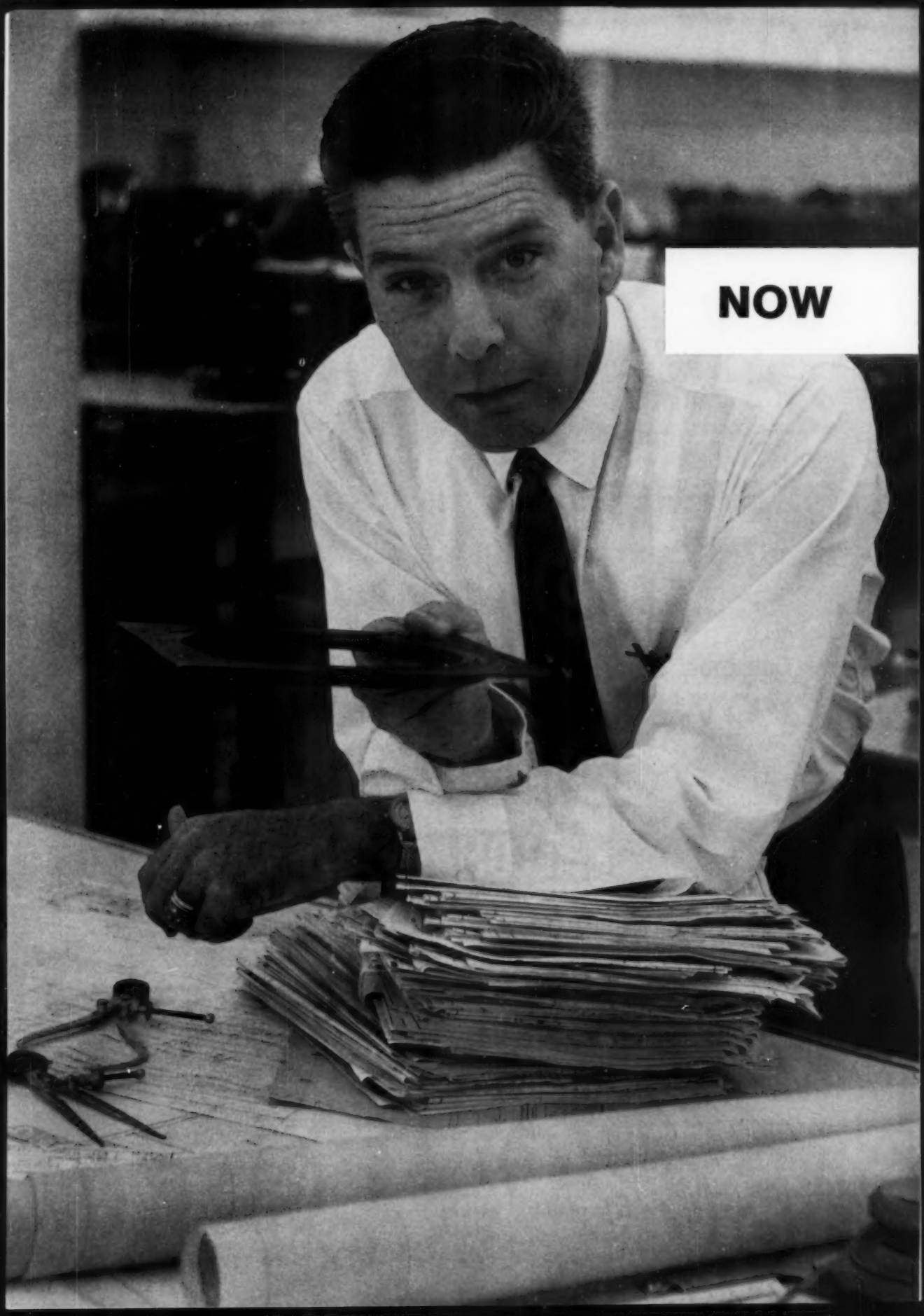
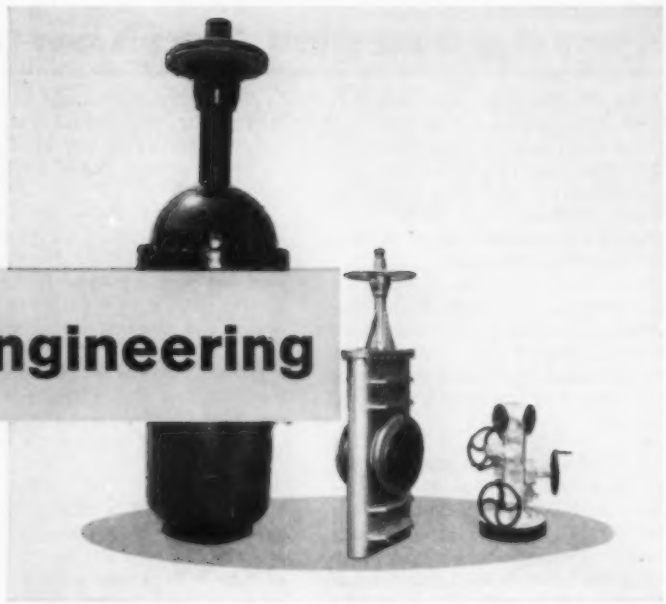

NOW

TOTAL Valve Engineering

112 IDEAS FOR THIS ONE W-K-M PART



Left to right above, W-K-M's new: *Safe-T-Seal* Gate Valve (ASA); Pressure Sealing Gate Valve (ASA); Cross-type Triple Gate Valve (API).

New valves are being developed to outperform any you've ever known

From 112 designs by W-K-M engineers came an unusual valve seat. It is the secret of performance in W-K-M's new Pressure Sealing Gate Valve . . . and a hint of things to come.

Under wraps in W-K-M's Research and Development Laboratory are experimental valves looking like none you've ever seen . . . prototypes being tortured to simulate a lifetime of hard service. And, in restricted field installations, new models with no marking or identification, are making their final test runs.

W-K-M's exhaustive research and development program is a vital part of TOTAL Valve Engineering—W-K-M's unique dedication to *all* phases of valve technology. From it come today's valves and valves of the future . . . designed to work better, last longer . . . on the world's toughest jobs.

W-K-M

DIVISION OF ACF INDUSTRIES
INCORPORATED
P. O. BOX 2117, HOUSTON, TEXAS

6002

Management Personals

John M. Shea Jr. and **Ralph E. Damp** were elected to the board of directors and as corporate vice presidents of American Petrofina, Inc. Shea is in charge of marketing of all the refined products, and Damp is in charge of all oil and gas production and exploration operations.

Lawrence J. O'Connor Jr. was appointed administrator of the Oil Import Program. He succeeds **Captain Matthew V. Carson Jr.,** USN, who has been administrator of the program from its inception.

Dr. Richard J. Gonzalez, who has been coordinator of finance and economics of Humble Oil & Refining Company, was elected a member of the board of directors. In addition to his assignments and duties as a director, he will be functionally responsible for finance and economics. **Herman P. Pressler Jr.,** now a vice president and member of the board of management of the Humble Division, was named vice president and manager of public relations in charge of directing and coordinating Humble's expanding public relations activities. In his new position, Pressler will be associated with **Joseph L. Seger,** former president of the Carter Division, who moved to the Houston headquaters as vice president for all public affairs (public and governmental relations).

Dr. Charles F. Jones, who has been serving as manager of the manufacturing department of the Humble Division, has been appointed to the newly-created position of manager of an economics and planning department.

James C. Downs Jr., chairman of the board of Real Estate Research Corporation of Chicago, was elected to the Christiana Oil Corporation's board of directors.

Edwin F. Nelson of Superior, Wis., has retired as president and director of Lake Superior Refining Co., however, he will continue to serve the company on a consultant basis.

John M. Brown, refinery manager for Lake Superior since February, 1959, was elected to replace Nelson on the board of directors and elected a vice president and general manager. **L. Russell Marks** of El Dorado, executive vice president of Murphy Corporation and a director of Lake Superior, succeeds Nelson as president.

Roy A. Clifford, Houston, has been promoted to assistant director of employee communications for Continental Oil Company. Formerly assistant manager of personnel relations for the petrochemical department, he will continue to make his headquarters in Houston.

Lacy W. Goostree Jr. was appointed manager of marketing in General Electric Company's computer department. He succeeds **George A. Hagerty,** who was named to the newly-established position of manager, process computers.

W. W. Green, vice president of Varel Manufacturing, was made general manager of Varel Afrique, new subsidiary of the drill-bit company. **Murray Hughes** was appointed liaison official between the home office and Algerian operation. **D. W. Varel** is president of the Dallas, Texas, concern.

Thomas P. Pike, vice president of the board of Republic Supply Company of California and executive vice president and a director of National Engineering Science Company, was elected president of the Standford University board of trustees.

Jack R. Mills has joined the oil and gas division of Citizens National Bank. He has been associated with Sunray Mid-Continent Oil Co. for the past nine years as division contract attorney and landman.

J. H. Walsh was named to succeed **Gordon R. Carpenter** as Eastern division sales manager by The Lufkin Rule Company. This move permits Carpenter to devote all of his time to the management of the Middletown, New York manufacturing division and office.

J. H. Walsh

George T. Piercy was appointed manager of coordination and petroleum economics department of Standard Oil Company (New Jersey). Assistant manager of the department since 1958, he succeeds **Charles J. Hedlund,** who is resigning to become a director and vice president of Esso Standard Italiana.

G. T. Piercy

Alessandro Zatti, director, becomes a vice president of Esso Italiana, and **R. T. Bonn,** presently with Esso Export Corporation, was named a director of Esso Italiana succeeding **E. G. Broming,** who transfers to Jersey Standard. **L. Pittaluga,** assistant comptroller of Esso Italiana, is appointed comptroller of that company to succeed **D. J. Thompson,** who resigns from Esso Italiana to become a member of the board of directors of Esso Switzerland.

C. J. Hedlund

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COULOMETRIC TITRATOR
FOR RAPID TITRATIONS AUTOMATIC

To determine if jet fuel meets specification of 1/1000 of 1% mercaptan sulphur. This device measures concentrations 1/10 of specification maximum—1/10,000 of 1% mercaptan content to meet precision of ASTM Methods. Titrates wide range of concentrations.

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▸ Three Continental Oil Company executives —**L. F. McCollum,** president, **Harold G. Osborn,** senior vice president, and **Wayne E. Glenn,** general manager of production, were presented honorary doctor's degrees.

McCollum was presented an honorary doctor of laws degree from Texas Technological College, Lubbock. An honorary doctor of science degree from University of Tulsa was received by Osborn. Glenn was presented an honorary doctor of engineering degree from Montana School of Mines, Butte.

▸ **Glen Tableman** was named manager-sales, and **Paul J. Natho** was named manager of the newly-created market development department. W-K-M Division of ACF Industries. The three district managers reporting to Tableman are: **Ross Spencer,** previously with market research department, manager — Southwest district; **Gaston T. White,** area supervisor for Lafayette, Louisiana area, manager — Southeast district; and **William Giffhorn,** supervisor of sales for North Louisiana and East Texas, manager— Mid-Continent district. Natho, directing the promotion of present products, new applications and new products, will have four product managers: **M. J. Conley,** oilfield; **Paul Nerren,** pipeline; **Bart Braznell,** refinery, **Bob Butler,** industrial.

▸ **D. C. Wixson,** administrative vice president for DX Sunray, was named administrative vice president for the Sunray family of companies. He will serve for Sunray and for its principal subsidiaries, DX Sunray Oil Co. and Mid-Continent Pipe Line Co. In his new capacity Wixson will assume a variety of administrative responsibilities heretofore handled by other officers.

▸ **H. C. Teasdel** was elected a vice president and director and **Glenn M. Forgan** a director of General Gas Corporation. Teasdel previously served as president and chairman of the board of The California Company. Forgan is vice president of The First National Bank of Chicago and serves as head of the Bank's Division which handles all phases of the institution's oil and gas financing activities.

▸ **J. Paul Jones** of Bradford was re-elected president and executive manager of Pennsylvania Grade Crude Oil Association. **G. J. Hanks** resigned as first vice president, however, he remains a member of the board. **Karney R. Cochran,** Bradley Producing Corp., who had previously served as second vice president, was elected first vice president. **A. C. Simmons** was elected second vice president. **Fayette B. Dow** was re-elected vice president and genral counsel and **Samuel Messer,** Quaker State Oil Refining Corp., was re-elected treasurer.

Re-elected as assistant treasurers were **W. A. Harper,** Quaker State; **Glenn E. Scott,** Wolf's Head Oil Refining Co., and **C. L. Suhr,** chairman of the board, South Penn Oil Company.

▸ **S. S. "Pete" Parker,** vice president and director of National Tank Company, has moved to California as president and general manager of National Sales Company, a wholly owned Subsidiary of the Tulsa-based firm. He will continue to be a director and vice president.

▸ **Herbert W. Johnson,** former manager of budgetary control for Kerr-McGee Oil Industries, Inc., was appointed management assistant. In his new position, Johnson's responsibilities will include special projects for top management as well as assisting in the evaluation of proposed capital expenditures. Succeeding Johnson is **Jack N. Fruits** who before joining Kerr-McGee, was budget and finance analyst in the foreign operations division of Sohio Petroleum Company.

▸ **Daniel B. Lovejoy,** senior vice president of Union Texas Natural Gas Corporation, was elected a director.

▸ **Robert O. Vaughan** was appointed as vice president, marketing of Southwestern Industrial Electronics Company, one of the Dresser Industries. Vaughan moves into the SIE position from his former post as western regional manager of government operations for Dresser Industries, Inc.

▸ **Thomas E. Fiske,** a senior attorney for Standard Oil Company (Indiana), assumed responsibility of representing the company in activities concerned with protection of the petroleum industry's established markets from effects of gasoline tax evasion or unethical practices. He also will supervise investigating and security formerly directed by **Frank V. Martinek,** retired.

European Firms Licensed

Grove Valve and Regulator Company, Oakland, California, has licensed two additional European firms to produce its G-4 gate valve. They are Nuovo Pignone of Firenze, Italy, and Robert Cort & Son, Ltd., Reading, England. Grove's French subsidiary, Grove France S. A., in Paris, has been producing G-4 valves since early in 1958.

Opens Foreign Division

Nuclear Consultants Corporation of St. Louis and Los Angeles announces the opening of a new international division in New York City. The offices are located at: Nuclear Consultants Corporation, International Division; 333 East 46th Street, New York 17, New York.

This new division will handle all export business of the firm with the exception of Canada, where Nuclear Consultants is represented by: X-Ray and Radium Company, Ltd., 261 Davenport Road, Toronto 5, Canada.

The firm handles radiochemicals: Cobium, tagged chemicals and biochemicals as well as dosimetry service and consulting services. Increased interest and sales in foreign markets has made this new division necessary.

DEAD WEIGHT GAUGE

Portable instrument conveniently measures line pressures, rock pressures at wells, static pressure on orifice meters, and gas pressure on pipe line leakage tests. Maximum pressure: 500, 1000 and 1500 psi. Graduations: 1 or 1/10 psi. Write for information.

No. 35250-1 $140.00 (*Prices to* $237.50 *depending on pressure and graduations.*)

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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

▸ **Edward H. Hermsen,** assistant corporate secretary, was elected corporate secretary of Tidewater Oil Company, succeeding **W. J. Burker** of New York.

▸ **Frederick P. Glazier** has joined Sun Oil Company as special assistant in the research and development division to be the principal liaison for Sun with the automotive and aviation industries. He will be special assistant to **John G. Moxey Jr.,** assistant director, motor products, in research and development.

▸ **Bruce W. Gambill,** acting manager of industrial relations for Sinclair Oil & Gas Company, Tulsa, was named manager of industrial relations.

▸ **Joseph F. Goetten** was appointed manager of the tax department of Standard Oil Company (Indiana), with responsibilities for tax matters concerning the consolidated company. Goetten succeeds **Eldon O. Hanson,** retired.

▸ **William F. Kenney,** vice president and general counsel of Shell Oil Company, was elected chairman of the Committee on Public Affairs of the American Petroleum Institute. He succeeds **Kerryn King,** vice president and general counsel of Texaco Inc.

F. R. Schmieder, general superintendent for Shell covering their Pacific Coast area operations, was appointed chairman of API National Committee on Supervisory Development, suceeding **Vernon Blacklock.**

▸ **O. V. Tracy** has retired as president of Esso Standard Division, Humble Oil & Refining Company. **William W. Bryan,** serving in Houston as vice president for marketing on Humble's headquarters staff, succeeds Tracy as president of Esso.

O. V. Tracy

W. W. Bryan

▸ **J. D. Parriott** and **J. S. Woodruff,** Ohio Oil Company attorneys, were transferred to Findlay, Ohio. Parriott moves from the company's office at Washington, D. C. Woodruff was transferred from the Tulsa offices.

▸ **Eric A. Bianchi,** vice president — engineering and manufacturing, was appointed general manager of the Mason-Neilan Division.

▸ **Craig M. Rowley** was elected president of Parkersburg-Aetna Corporation following the elevation of **Bernard P. McDonough** to chairman of the board of directors. McDonough continues as the chief executive officer. Rowley formerly was a vice president of the corporation and president of The Parkersburg Rig & Reel Company Division.

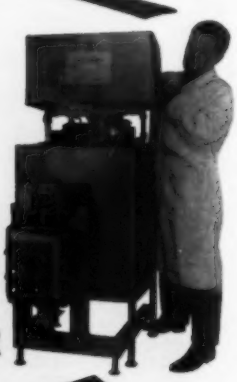
▸ **Dr. Robert L. Lembke** took the position of staff physician in Continental Oil Company's medical division, at Ponca City, Oklahoma. Dr. Lembke assists **Dr. W. O. Armstrong** and **Dr. Robert R. Dugan,** in administering Conoco's company-wide medical and health programs.

▸ **J. Delano Hitch Jr.,** president and a director of Dorr-Oliver, Inc., Connecticut, resigned as chairman of the board of directors. Hitch will continue to be active as a director and a consultant under long-term contract. No successor is named.

▸ **P. F. Hawkins,** manager of program division, becomes manager of Esso Standard's supply department. He succeeds **D. B. Voorhees,** the new manager of foreign division of traffic department. **P. B. Harman,** followed by Voorhees, moved to supply as assistant manager of new operations division

For blending crude oil products . . .

NEW SINCLAIR -CENCO GRAVITOMETER



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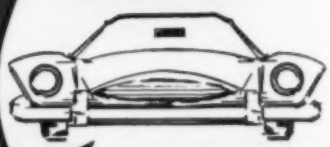

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NOW AT HOUSTON INTERNATIONAL AIRPORT

responsible for operations coordination. **R. R. Quincy,** head of new projects section, becomes assistant manager to **K. O. Johnson,** manager of economics division. **J. A. Dimock,** former assistant manager of economics division, transferred to operations division as assistant manager responsible for operations analysis.

▸ **E. V. Murphree,** president of Esso Research & Engineering, scientific affiliate of Jersey Standard, was elected to the board of directors of the Atomic Industrial Forum, association of nuclear industry.

DEATHS

▸ **Leonard P. St. Clair,** pioneer California oil man and a former president of Union Oil Company passed away after a long illness. Mr. St. Clair was 89 years old.

▸ **Herbert J. Weeks,** 62, geological counselor to Sun Oil Company's foreign operations department and vice president of nine subsidiary companies engaged in foreign exploration and production, died on June 13, in Philadelphia.

▸ **David T. Shaw,** a retiree and former manager of The Atlantic Refining Company's Philadelphia refinery, died on July 1 in Lankenau Hospital (suburban Philadelphia). He was 66 years old.

▸ **Frank V. Long Sr.,** 60, president of Vapor Recovery Systems Company, suffered a fatal heart attack in his Whittier, California home, June 27.

CLASSIFIED

ADVERTISING SALES OR PROMOTION

Trainee for leading oil, gas, petro/chem publications. Must be personable, intelligent, tactfully aggressive. He could be a graduate in advertising, marketing, journalism, or a petroleum, mechanical or chemical engineer presently employed in the oil-gas industry. Writing aptitude important. Excellent opportunity for young man of right qualifications. *Apply by letter and resume to* **P. O. Box 1589, Dallas, Texas,** *sending qualifications, telephone number and photo. Replies will be held in confidence.*

POSITION SOUGHT

Industrial advertising and promotion man seeks position in Dallas, Texas, area. Can offer 15 years successful handling of complete programs or special campaigns for Original Equipment Manufacturers. Heavy experience in planning, creating and preparing advertisements and literature for technical equipment. Currently own and operate nationally-recognized advertising agency in Pennsylvania. University trained; 43; married; two children. Salary required. $12,000. *Complete resume on request. Write: D. B. Hewitt, R. D. #1, Homer City, Pa.*

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The JEFFERSON with its new facilities for handling all convention groups is fast becoming Atlantic City's most popular convention hotel. The JEFFERSON features an abundance of Meeting, Banquet and Exhibition Rooms fully equipped to handle your every need. Experienced personnel. Location ideal in heart of Atlantic City.

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ROOMS *from—* $4.50 *per day single* $6—*double and you can budget* MEALS *at* $4.50 *per day*

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100% Airconditioned
600 Bright *Reasonably* Priced Rooms

THE MAYO
TULSA'S *Finest* HOTEL
Sample Rooms – Finest Food
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NATIONAL'S Revolutionary MANI-FLO® VALVE

PATENT APPLIED FOR

The MANI-FLO valve, through unique design, lends itself to wide use in the production of oil and gas. Designed primarily for use in lease well production manifolds to eliminate the problems and expenses of conventional arrangements consisting of cumbersome piping, standard valves and fittings, it may also be used as a three-way valve for blending two streams for temperature control; for mixing two different liquids or gases; or as a switching valve to divert flow to different tanks or lines.

In any role or application, MANI-FLO valves may be hydraulically, electrically or diaphragm controlled and sensed by liquid levels, pressures, temperatures, times or differentials of these.

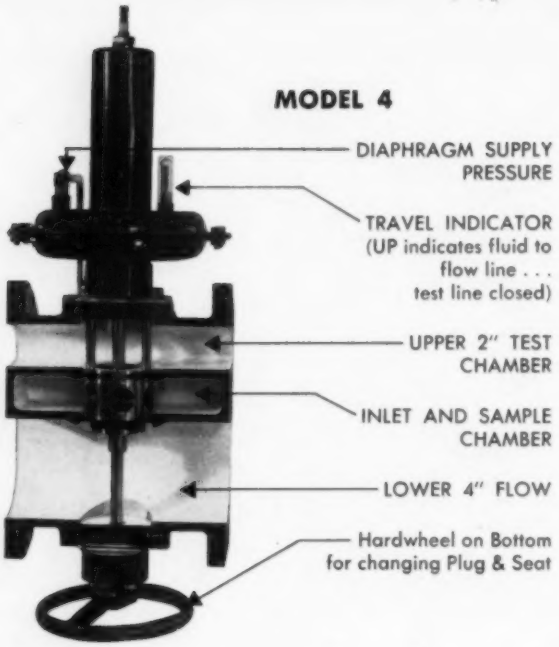
MANI-FLO valves may be installed in a horizontal line with diaphragms and/or handwheels either vertically or horizontally, or valves may be stacked vertically from ground up with controls pointing in any direction.

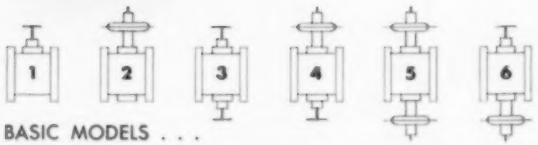
TYPICAL SPECIFICATIONS:

SIZE: 2" screwed inlet — 2" test outlet — 4" flow outlet — ½" sample connection opposite 2" inlet.

WORKING PRESSURE: 600 PSI. Test Pressure 1200 PSI.

MATERIAL: Body and Body Cover Flanges — Ductile Iron. Diaphragm Case — Pressed Steel. Plug, Seat and Cage — Type 303 Stainless Steel. Plug has Buna N synthetic rubber molded to 303 to give same sealing characteristics as "O" ring for tight shut-off. Metal-to-metal contact between plug and seat to prevent extrusion of rubber and to take excess force applied to seat and plug when closed.


MODEL 4
DIAPHRAGM SUPPLY PRESSURE
TRAVEL INDICATOR (UP indicates fluid to flow line . . . test line closed)
UPPER 2" TEST CHAMBER
INLET AND SAMPLE CHAMBER
LOWER 4" FLOW
Hardwheel on Bottom for changing Plug & Seat



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- VERSATILE . . . for line pressures 600 PSI or less:
  a. May be used as a shut-in valve
  b. Six different models for various applications to choose from
- PRACTICAL . . . travel indicator or positive flag
- SALVABLE . . . bolt it in or un-bolt it
- LONG-LASTING SAFETY . . . ductile iron bodies with stainless trim, tested to 3,000 PSI
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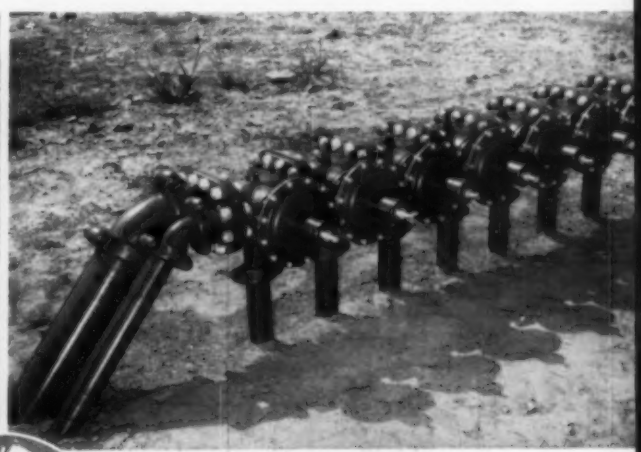
- LOOKS THE PART . . . Judge for Yourself!



For prices and more information, state model number and quantity. Address . . .

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Here's a heavy weight that's really light on its feet. A 32,000 lb. capacity Cabot Air Balance Unit with a 100 inch stroke weighs 50% to 60% of a crank balanced unit with full counter-weighting. What does this mean to you? Plenty! It means less transportation costs to location, less foundation costs, easier and safer erection, easier moves. This heavy weight is not only light on its feet — it's light on your pocketbook, too!

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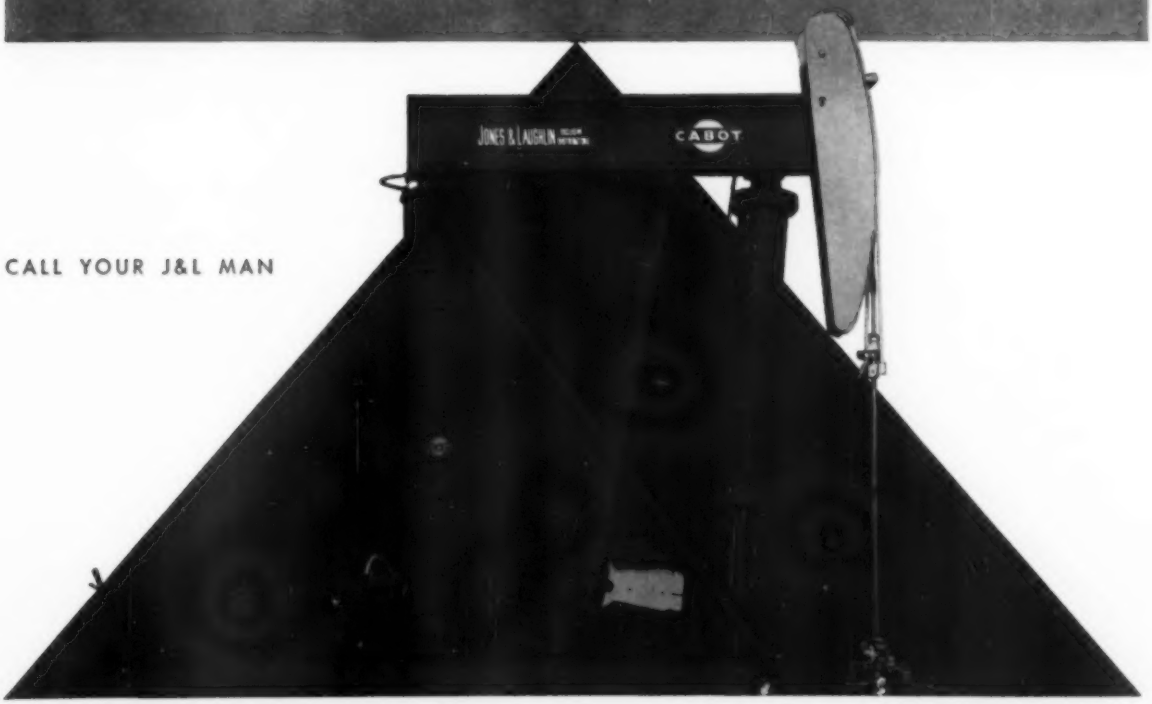

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What Is Your P.W.C. Problem?

Welex Puts the "COMPLETE" In Permanent Well COMPLETIONS

Do you have a difficult well to complete—or a special PWC workover problem that you can't solve?

Do you need a perforating gun to run through tubing as small as 1½" ID—or in a multiple completion, do you need to perforate along a tubing string without risk of damage to the string?

Just WHAT is your PWC problem? If it can be solved, Welex can solve it.

Welex, which recently added the Sidekicker to its list of Permanent Well Completion tools, now offers the most complete selection of PWC services to the industry.

Whether single or multiple completion, Welex on your well assures fast, safe and accurate service with a minimum of delay. That's why many Welex services and tools are standards of the industry, including:

Perforating

SWING-JET*—The standard of the industry for use in through-tubing work where maximum efficiency is desired. The carrier can be run through tubing as small as 1½" ID with seating nipple.

LINK-JET*—Here is a perforator for use in small diameter casing or for through-tubing work. The amount of debris left in the hole has been reduced.

SIDEWINDER*—Originally designed for tubingless completions, this gun leaves absolutely no debris in the hole, and when used with the Sidekicker, it perforates PWC well effectively without risk of damage to adjacent tubing strings extending downhole.

SIDEKICKER—A mechanical orienting decentralizer, the Sidekicker positions the jet gun so that the charges fire outward through the casing at maximum efficiency—never in the direction of the adjacent tubing strings in multiple completions. The Sidekicker and retrievable gun carrier can be run and retrieved through 2" ID tubing and seating nipple.

Remedial PWC Services

Welex services and tools include everything needed for later remedial work on PWC wells. These include such standards as the:

- Through-Tubing Bridge Plug
- Through-Tubing Dump Bailer
- Flo-Master Flowmeter Survey
- Radioactive Surveys
- Tracer Surveys
- Temperature Surveys
- Welex Jet Tubing Cutter

In Permanent Well Completions, as in other types of completions, a complete package of tools and services means time saved and money saved. That's why Welex is your best choice every time.

Let Welex's complete completion services serve you.

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Of Things To Come . . . In Oil

OFFSHORE COSTS ARE COMING DOWN, according to K. H. Crandall, vice president, exploration, Standard Oil Company of California. Speaking before the 1960 convention of the American Association of Petroleum Landmen, Crandall foresaw the brighter picture resulting from: The permanent platform with its expensive tender giving way to the mobile rig and floating vessel; drilling contractors bidding lower to remain competitive; where reservoirs permit, the trend toward multiple completions; surplus equipment that was stored away during the 1958 depression being used to reduce expenditures for new rigs, tenders, etc.; high-cost barging replaced by a network of pipelines; underwater completions receiving increased attention from researchers.

HOLLAND WILL JOIN OFFSHORE SEARCH in 1961 when the "Triton" will drill 3 wells off the coast of South Holland for N.V. Nederlandse Aardolie Maatschappij (N.A.M.), in which company Bataafse Petroleum Maatschappij (B.P.M.), of the Royal Dutch/Shell Group, and Standard Oil (New Jersey) each have an equal interest. Actual drill sites will depend upon results of seismic exploration of deeper strata under the seabed.

DEVELOPMENT OF ATHABASCA TAR SANDS is a long way off in spite of Alberta Government's recent order for a new study of the area. Order resulted from request for rights made by Great Canadian Oil Sands, a new group interested in producing the sand-locked oil. However, the government wants only one firm to prove commercial possibilities of the sands on a small scale. Reason: Alberta can produce from conventional fields more than it can sell.

CANADIAN EXPLORATION WILL INCREASE, especially in the Arctic island area, as a result of recent permits totaling 44 million acres. Mobil Oil of Canada has already started a marine seismic survey in the Sable Island area. Other holders of Arctic territory are Cree Oil of Canada and Dominion Explorers.

PEMEX WILL PRODUCE 320,000 BBL PER DAY by the end of the year according to the Mexican monopoly's director, Pascual Gutierrez Roldan. Present production is 308,000 bbl per day. Roldan also announces that French interests have invited Pemex to join them in developing oil in the Sahara.

ATLAS EMULSIFIER saves $15,125 in 5000′ comparison

Carper Drilling Company of Artesia, New Mexico, is typical of contractors and operators that have been able to effect substantial savings in drilling costs by using an Atlas emulsifier. Here is a direct comparison of the drilling records of Carper's State MA-A #1, located in Lea County, New Mexico, Section 31, 17S, 33E, and an offset well in Eddy County, Section 29, 17S, 31E. Both wells were drilled about the same time through the same formation to a total depth of 10,000 feet. The rig used on the Carper well was smaller, having lower power, hoisting, and hydraulic capacity. The comparison well, using a low-solids CMC mud, required over twice as many bits at an additional cost of $7,425; difference in rig time accounted for another $7,700 . . . a total of $15,125 in tangible savings.

DRILLING RECORD COMPARISON

	STATE MA-A #1	OFFSET WELL
Mud	Atlosol emulsion	low-solids CMC
Interval	5,123′-10,015′	5,263′-10,011′
Feet Drilled	4,892	4,748
Rig Hours	857	997
Feet per hour	5.7	4.8
Bits	27	60
Feet per bit	181	79
Weight on Bit	30,000-45,000#	60,000-65,000#
Drill Pipe	3½″	4½″
Drill Collars	17—6″ x 2¼″	20—7″ x 2¾″
Pumps	1—18″ 1—14″	2—20″
Liner Size	5½″	6½″

Atlas emulsifier is sold through distributors under these tradenames . . . each is the product of Aquaness Department, Atlas Powder Company:

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Atlas Emulsifiers Improve a Good Drilling Fluid.

Better Hole Conditions. Torque is decreased as much as 50% . . . the hole is kept cleaner and pump pressures are correspondingly lower. There is less danger in loss-circulation and low-pressure zones.

Longer Bit Life. Prevents balling, provides better cutter and bearing lubrication. Greatly extended bit life reduces bit costs, reduces rig hours lost to trip time.

Faster Drilling Rates. More feet of hole per hour. Oil lubrication combines with improved hole condition to increase drilling rates in competent and troublesome formations.

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Now you get Continental-Emsco's field proven slush pump engineering and quality control in all sizes . . from the smallest to the largest.

FABRIFORM POWER END . .
easier handling around the rig . . lighter weight without sacrificing strength.

COMPACT GEAR DESIGN . .
less weight but more than adequate capacity for today's increased horsepower requirements.

ROLLER BEARINGS . .
free rolling action cuts load on prime mover . . extends service life . . no field adjustments required.

REPLACEABLE CROSSHEAD GUIDES . .
easy replacement reduces maintenance and down time . . greatly extends usable life of pump . . slippers can be replaced in larger pumps.

AUTOMATIC LUBRICATION . .
all parts are automatically lubricated regardless of pump speed.

STEEL FLUID END . .
designed to handle all muds at highest operating pressures with maximum efficiency.

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safeguards against fluid end washouts caused by packing failures.

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speed up valve inspection, servicing and replacement. Assure maximum fluid flow with minimum turbulence.

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assure uniform pressure on packing . . eliminate uneven packing wear, cause of premature packing failure and rod scoring.

Check these features. See why overseas operators, drilling in remote areas, have more confidence in Continental pumps. Regardless of your operation . . local or worldwide . . buy Continental pumps and take advantage of their ability to pump more mud at lower cost.

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DA-850—Maximum input . . 850 hp @ 60 rpm
DA-700—Maximum input . . 700 hp @ 60 rpm
D-550—Maximum input . . 550 hp @ 70 rpm
D-375—Maximum input . . 375 hp @ 70 rpm
D-225—Maximum input . . 225 hp @ 70 rpm
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Here's the most complete, most efficient line of perforating services available to the oil industry – all designed with one objective – to get more oil, *best* possible production!

Choice of the type perforating process to be used depends on the nature of the formation to be penetrated and the method of well completion; whether in full size casing, thru-tubing or in slim holes.

At McCullough you'll find bullet and jet guns, in a variety of types and sizes, to handle every requirement – quickly, efficiently and profitably – your *best* bet for *best* production!

FOR PERFORATING IN CASING

McCULLOUGH BULLET GUNS – World's hardest shooting bullet guns. Best available perforating process in all formations except extra hard.

McCULLOUGH GLASS JET GUNS – Most versatile and efficient of all jet casing perforators. Deep penetrating, carrot-free, junk-free. Uses flexible, retrievable Steel Strip Carrier. Gets best results in hard formation.

McCULLOUGH TUBULAR CASING JET GUNS – Star Jet, DuPont, Dynajet and Super Dynajet charges are available in most areas to meet varying well conditions.

TORPEDO JET GUNS, expendable type perforators for cased and open hole operations. Offered in limited areas.

FOR THRU-TUBING AND SLIM-HOLE PERFORATING

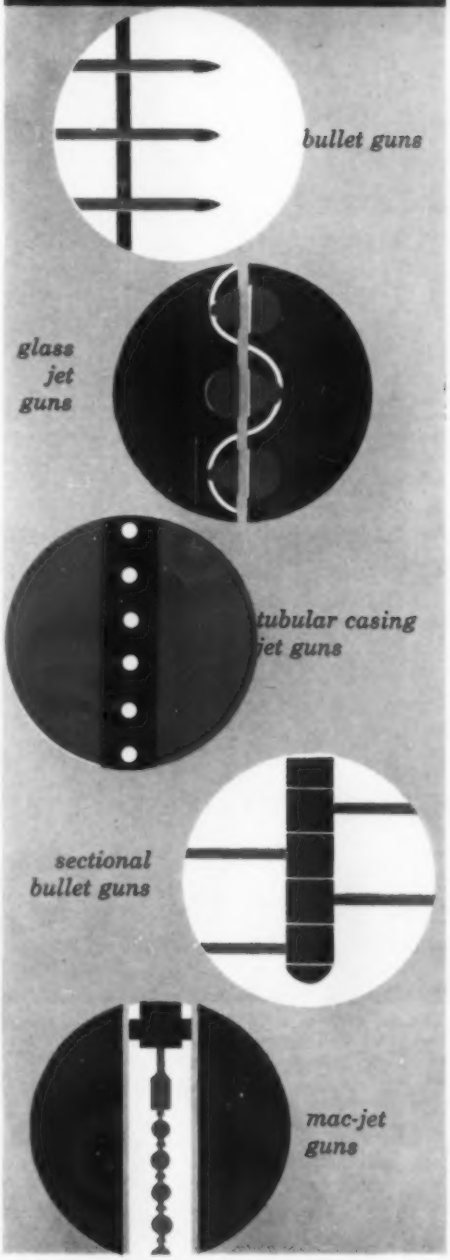
McCULLOUGH SECTIONAL BULLET GUNS – Only small diameter bullet guns made. Sizes are 1⅛", 1¾" and 2¼" OD. Backed by a record of more than 20 years of fine performance.

McCULLOUGH MAC-JET GUNS – Finest and most advanced of all small diameter, expendable jet guns. Features include enclosed firing system, minimum debris, deep penetration, high well flow index, carrot-free. Widely used in both thru-tubing and slim hole work.

OTHER SMALL DIAMETER GUNS include the **LINK JET** and **TORNADO JET,** expendable thru-tubing perforators; and the **SIDEWINDER,** a retrievable jet perforator for slim hole operations.

SPECIAL APPLICATIONS

McCULLOUGH FOUR-WAY SQUEEZE JET GUNS – designed to assure even distribution of cement around casing. **FRAC-JET** – fires eight jets on a horizontal plane for fracture placement.



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MISSION LIGHTWEIGHT SLIPS BUILT LIKE A BRIDGE FOR STRENGTH AND LIGHTNESS

MODEL 60

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Field and laboratory tests proved that these slips are built like a bridge with plenty of strength but no excess weight. They weigh only 135 pounds; so you won't break your back setting them. Yet, they have all the heavy-duty features you will ever need. You can hold drill pipe with hook loads of 275,000 lb. and drill pipe sizes 2⅜" through 5". The lightweight results from a new design based on sound and proved engineering principles.

Mission Rolling Dog teeth grip the hardest pipe available today with minimum stress concentration. New positive lock retains dogs in place. The standard rolling dogs and new solid inserts let these slips do the job of the heavyweights. You will find all the proved and popular Mission slip features: Segments are self-leveling as insurance against crimping the pipe. Top of slips is constructed to allow heavy elevator blows to be absorbed. Renewable hinge pins on these Lightweight Slips mean long life, less replacement. Flexible handles bend instead of break.

These new slips — built like a bridge — are one more proof Mission knows drilling problems and knows how to overcome them. Available at your supply store.

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1.

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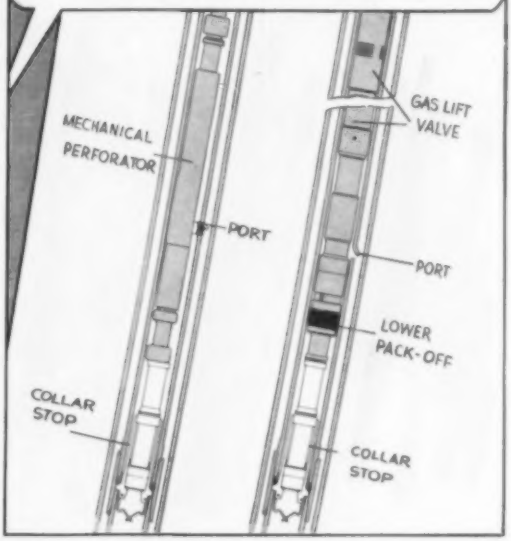
$350,000.00

IN WORKOVER COSTS LAST YEAR.

IT'S THEIR TYPE C GAS LIFT VALVE RUN WITH A TYPE G REMOVABLE TUBING PACK-OFF ANCHOR. WITH IT OTIS CONVERTED A NUMBER OF OUR OLD WELLS TO GAS LIFT WITHOUT PULLING THE TUBING — AND THEY WERE WELLS THAT WERE ORIGINALLY COMPLETED WITH NO PROVISIONS MADE FOR GAS LIFT.

2.

The technique Otis uses in this type of recompletion is simple and fast. First, their gas lift specialists determine the number of valves required and the proper spacing. Then they cut a port in the tubing with a wire line mechanical perforator and pack-off their gas lift valve opposite the perforation. A full opening tubing stop locks the tool in the tubing. To give you some idea of the capacity of this type of installation, WE'RE MAKING 1,200 BARRELS OF FLUID PER DAY THROUGH 2" TUBING FROM ONE OF THESE WELLS.

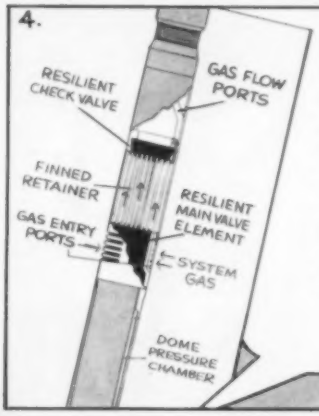


3.

And this Otis pack-off gas lift completion technique is one of the most foolproof we've ever had. For example, we know each valve straddles the port in the tubing because the lower pack-off anchor is landed on the same Otis collar stop used to locate the perforator. Also each check valve and pack-off can be tested as it's run by pressuring up on the tubing. And because the pack-off elements are set against the tubing wall mechanically, we know they'll stay expanded. Here's how the pack-off elements work.

CONNECTOR SUB
JARRING ACTION DRIVES CONNECTOR SUB DOWN TO EXPAND RUBBER PACK-OFF ELEMENT—
RATCHET LOCK
RATCHET LOCK HOLDS CONNECTOR SUB AGAINST EXPANDED ELEMENT
RUBBER PACK-OFF ELEMENT

4.



As for Otis Gas Lift Valves — this diagram will help explain why THEY REALLY LIFT THE FLUID. They have no spread — consequently you get maximum efficiency from your system gas. The valves have no moving metal parts, no bellows to fatigue, no seats to cut out — and they have extra flow ports to pass a maximum amount of gas at a minimum pressure. With Otis valves in your well you can produce by either continuous or intermittent lift — without the expense of changing valves.

Otis tells us they run a lot of these pack-off gas lift valves to straddle old style "piggy back" valves and eccentric side pocket mandrels when they become defective. They also install them in dual- and triple-completions. BEFORE YOU PULL TUBING to put any of your wells on artificial lift, I suggest you GET IN TOUCH WITH OTIS and talk to their gas lift specialists. We did, and it gave us some of the most economical and efficient gas lift installations we've ever had. It's no wonder Otis has the reputation of being

"First in Gas Lift Control"

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. . . is with a Johnston Drill Stem Test. Gives you information on which you can base a decision and be absolutely sure. It removes all doubt, actually puts you in touch with the formation. • Don't chance setting casing on a dry hole — don't pass up a producer.

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LOW-DENSITY CEMENT

No loss to weak formations

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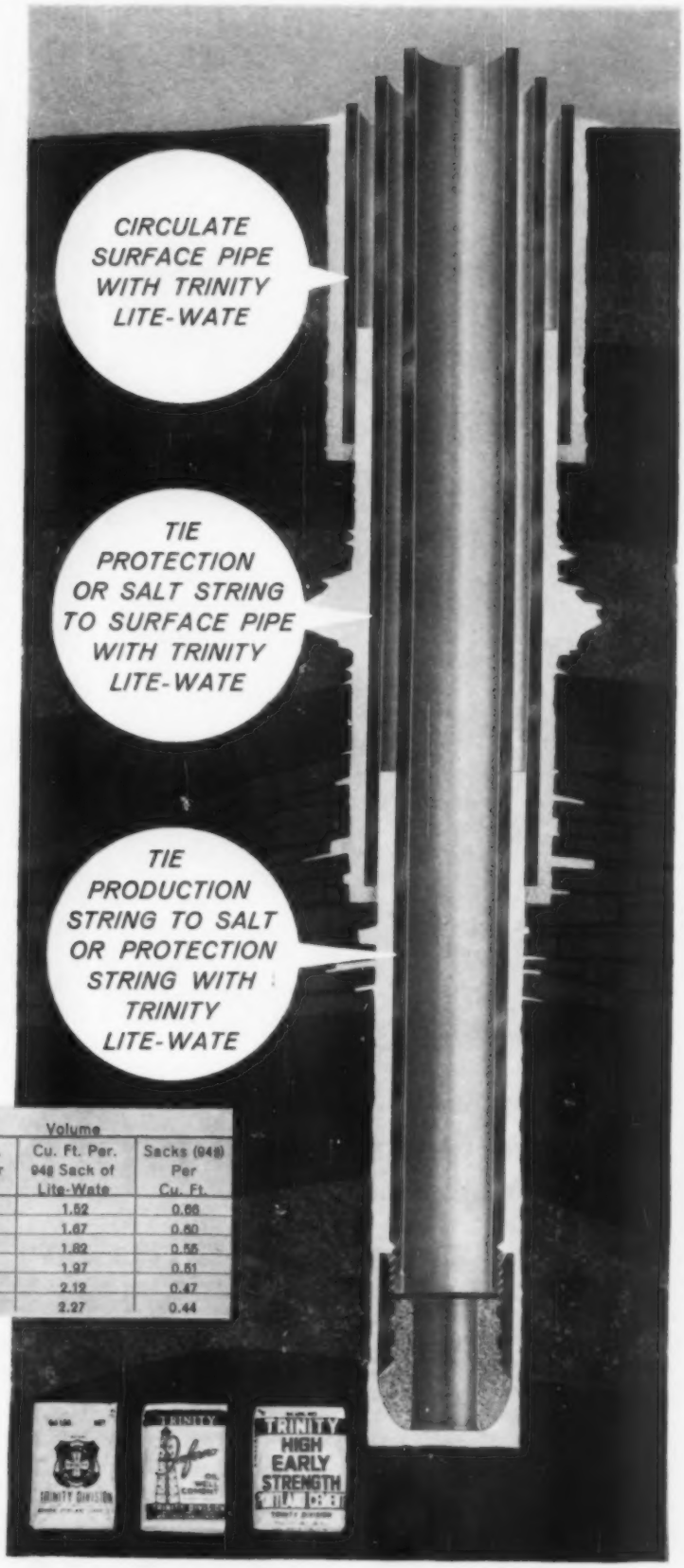
Trinity Lite-Wate has been in use for several months in such varying well conditions as found in West Texas, Oklahoma, East Texas, Louisiana, Gulf Offshore and New Mexico, it has produced returns in *every case* where attempted.

SLURRY PROPERTIES

All slurries were mixed in accordance with procedures in API RP 10B. Slurry weight and volume were calculated on the basis of Lite-Wate specific gravity of 2.80.

Mixing Water			Volume		
Per cent	Gallons Per 94# Sack of Lite-Wate	Initial Viscosity Poises	Slurry Wt. Pounds per Gallon	Cu. Ft. Per. 94# Sack of Lite-Wate	Sacks (94#) Per Cu. Ft.
90	7.39	13	13.56	1.62	0.66
75	8.42	6	13.16	1.67	0.60
80	9.58	4	12.77	1.82	0.55
85	10.72	3	12.44	1.97	0.51
100	11.84	2	12.14	2.12	0.47
115	12.97	1	11.89	2.27	0.44

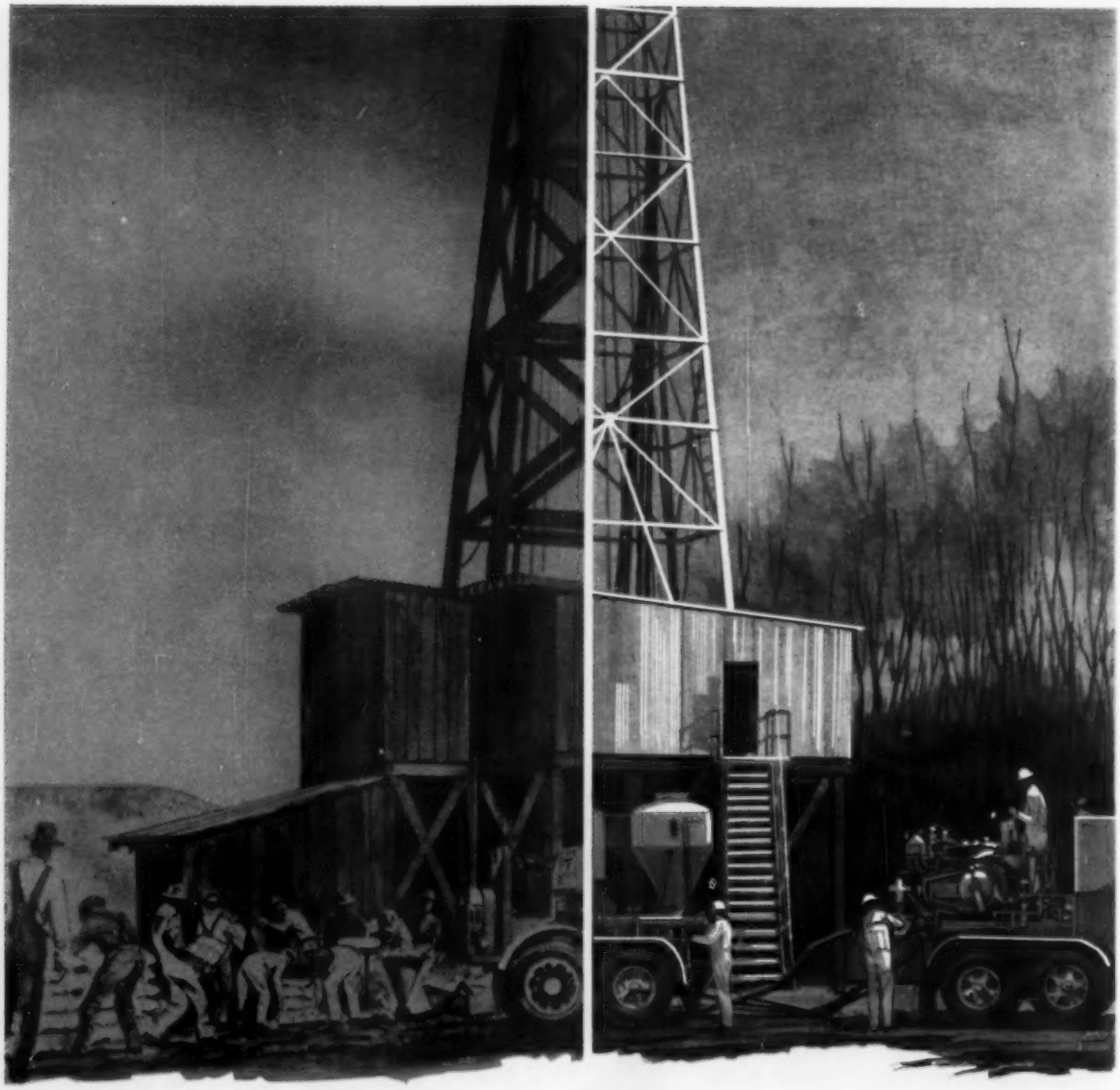

CIRCULATE SURFACE PIPE WITH TRINITY LITE-WATE
TIE PROTECTION OR SALT STRING TO SURFACE PIPE WITH TRINITY LITE-WATE
TIE PRODUCTION STRING TO SALT OR PROTECTION STRING WITH TRINITY LITE-WATE
TRINITY
TRINITY HIGH EARLY STRENGTH

TRINITY

PORTLAND CEMENT DIVISION
GENERAL PORTLAND CEMENT COMPANY

DALLAS·FT.WORTH·HOUSTON

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



EXPERIENCE...

The best additive to any cementing job

The old and the new – every phase of an oil well cementing job has changed considerably in the span of years represented by this composite illustration – except *one*. That one thing is the wealth of *experience* of the Halliburton men on the job. In 1924 – or the day after tomorrow – our *experience* is your key to confidence. Couple this experience with the finest equipment – like the powerful Halliburton HT-400 cementing units . . . pneumatic bulk cement handling units pioneered *first* by Halliburton . . . the multitude of well completion tools sampled on the next page – and you have an unbeatable combination. Talk to your nearby Halliburton man before your next cementing job. He will show you how Halliburton experience will work for you.

FOR FURTHER INFORMATION ON
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ALWAYS REMEMBER
THESE IMPORTANT CASING TOOLS

Roto Wall Cleaner installed with EZ Lok Clamps

HALLIBURTON ROTO WALL CLEANERS

. . . effectively "extend out" and clean off filter cake from the well bore. The stout metal fingers on each Roto Wall Cleaner are designed to remove filter cake as the casing is rotated.

HALLIBURTON RECIPO WALL CLEANERS

. . . provide another excellent means to clean the well bore of filter cake and help prevent cement channeling. Raising and lowering of the casing literally turns the heavy rubber fingers on this type cleaner "inside out" for maximum cleaning effectiveness.

Recipo Wall Cleaner

HALLIBURTON MODEL S-3 CASING CENTRALIZERS

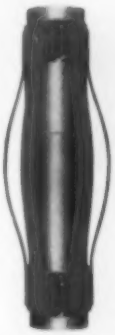
. . . are designed to help keep the casing centered in the hole and further aid in the prevention of cement channeling.

HALLIBURTON CEMENT BASKETS

. . . are designed to support the cement column above porous formations, or to separate stages in a multiple stage cementing job.

HALLIBURTON EZ LOK LIMIT CLAMPS

. . . are inexpensive, easy to install, and are designed to *stay put* on the casing until the job is completed. They can be used to install all of the tools listed above.



Model S-3 Centralizer

Cement Basket

EZ Lok Limit Clamp

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Applications include sand washing techniques, multiple completion, separate zone water flooding, permanent well completions.

Save possible damage to producing formations . . . . save pulling tubing . . . . install Camco Side Pocket Gas Lift Mandrels. Over 35,000 Retrievable Valve Mandrels in service in 17 different countries prove operator acceptance throughout the world.

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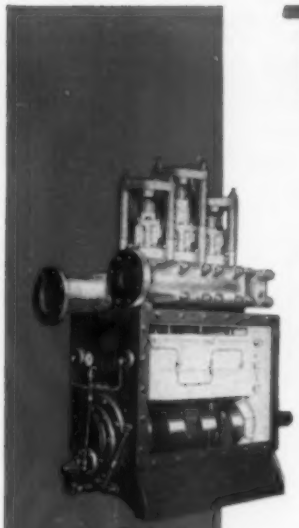
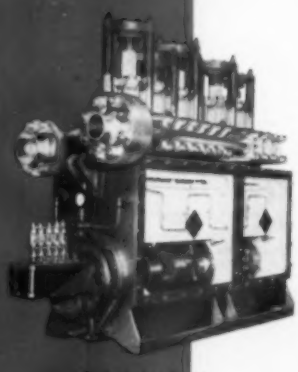
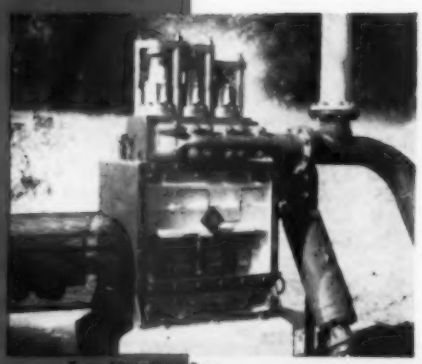


Triplex Pump



Quintuplex Pump



Type TPLL 5372 Pump

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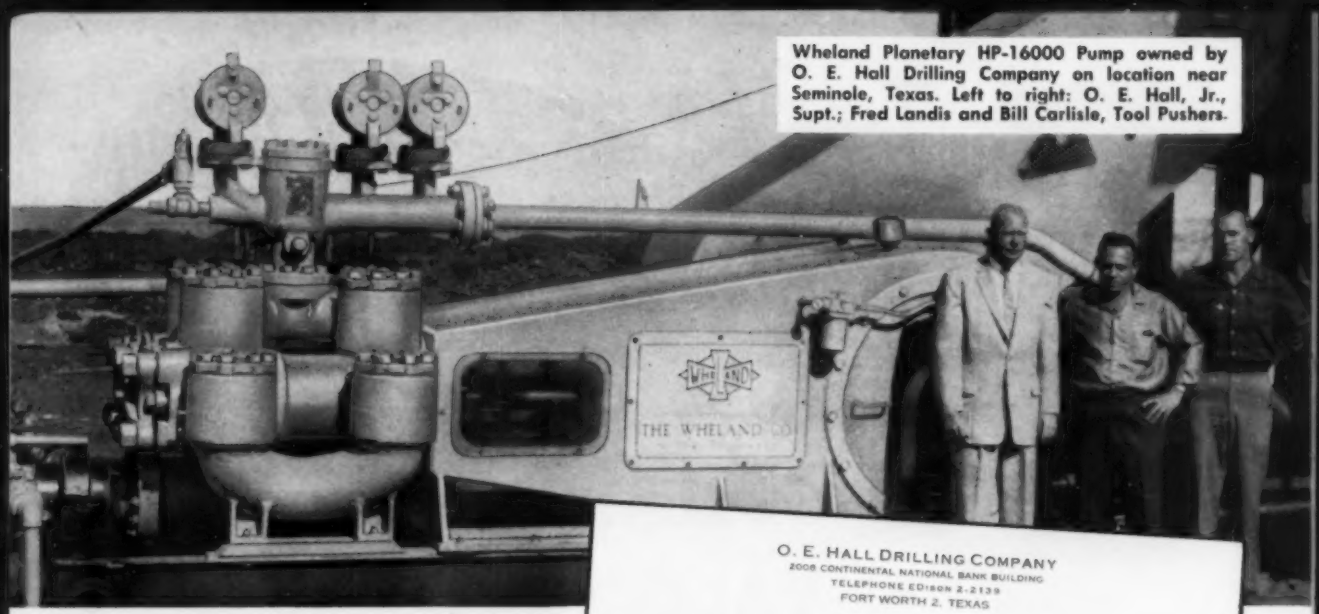
- Mid-Continent Supply Co. — Fort Worth, Texas



Wheland Planetary HP-16000 Pump owned by O. E. Hall Drilling Company on location near Seminole, Texas. Left to right: O. E. Hall, Jr., Supt.; Fred Landis and Bill Carlisle, Tool Pushers.

"... the pump has improved our operation ...we will be happy to recommend it."

O. E. HALL, Jr.

O. E. HALL DRILLING COMPANY
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TELEPHONE EDISON 2-2139
FORT WORTH 2, TEXAS

February 16, 1960

The Wheland Company
Signal Mountain Road
Chattanooga, Tennessee

Mr. Gordon L. Smith, Jr.
Manager Rotary Drilling Equipment Sales

Dear Mr. Smith:

We thought you would be interested to know how pleased we are with the performance of our Wheland Planetary HP-16000 Pump. It is the smoothest running pump we have seen. The big gear reduction makes possible such a small sheave and the pump pulls very easily. We are also impressed by the compactness of the gear cartridge and the smooth performance of the new circular crosshead. In the several wells we have drilled thus far the pump has improved our operation in terms of penetration rate and savings in bits. Also has exceeded our expectations.

All of these wells have been located in West Texas. We operate our rigs throughout the Permian Basin covering a depth range of 4, 500 feet to 12, 500 feet with modern equipment.

We want to commend The Wheland Company for stepping forward with this improved design in slush pumps, and we will be happy to recommend it.

Very truly yours,

O. E. HALL DRILLING COMPANY
O. E. Hall Jr.
O. E. Hall, Jr.
Midland, Texas

WHELAND PLANETARY HP-16000 PUMP

Duplex Power Slush Pump

7 ¾" x 16", 600 HP at 65 RPM

WHELAND

ROTARY DRILLING MACHINERY

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usi **Axelson PUMPING NEWS**

Multiple Completions Up 65% Axelson Expands Special Products

2-ZONE PUMPS

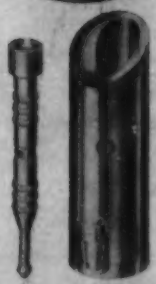
TWO-PACKER SINGLE STRING

Cross-Over Assembly

Least expensive for dual zone completions

SINGLE-PACKER DOUBLE-STRING

Clamped Tubing Cross-Over and Stab Joint Cross-Over Assembly



Most widely-used Axelson Two-Zone Pump, allows treating or gas venting the upper zone

ONE-PACKER TRIPLE STRING

Clamped Tubing Cross-Over

Used where the lower zone presents gas or corrosion problems. Both zones may be vented or treated.

As early as 1953 Axelson had a well-established Two-Zone Service Department when Texas was averaging less than 300 multiple completions per year. Now, with multiple completions up 65% over 1958, and running as high as 2200 per year in Texas, Axelson continues to expand its staff of full-time field specialists and engineers to handle the upswing of this type of completion.

Much has changed. Completions that once presented problems and seemed impractical are now considered routine due to Axelson's experience and advanced engineering design. Past complexities have been simplified and Axelson's know-how, specialized equipment and experience are available to all. Axelson's Two-Zone Department, now called Special Products Department, covers every multiple zone producing field in the United States and deals with both new completions and existing installations. They are also available to make recommendations on triple completions and slim hole duals or any phase of special multiple completion engineering.

Although their primary function is designing setups for multiple zone completions to take advantage of the production economies afforded by Axelson Two-Zone Pumps, Axelson experts work out production problems and make recommendations where one zone may be producing gas and the other oil, or where one zone is flowing and the other is pumping.

Axelson Two-Zone Pumps provide a practical, economical method of producing from two zones at once without commingling the fluids. Only one surface pumping unit is required, with a single rod string. All pump parts, with the exception of the cross-over assemblies, are standard, field proved parts, and the Two-Zone Pump itself is an insert-type pump, completely retrievable. A metal-to-metal seal is used for long life and dependability.

While the pumps themselves might be termed standard units, no multiple-zone completion can be called standard. No two wells present the same conditions, so each Axelson dual zone installation is in effect custom designed.

When an Axelson two-zone specialist is called in to discuss a multiple zone installation, he takes into account: pump depth (for both zones), casing size and length, tubing, water cut, gravity of the oil, desired production and the gas/oil ratio. The surface pumping unit—peak load and torque ratings, stroke length and maximum cycle, size—also enters the calculations, as well as such special conditions as sand, viscous fluid, and corrosion. He can also recommend the best tubing string design, the prime mover, surface pumping unit, packer type and rod string.

When the installation is made, he will supervise it at no extra charge—set the pumps and packers, and be on hand for the initial pump running—to make sure you have an efficient, economical production setup.

Call in your Axelson specialist and let him work with you in engineering your multiple zone installations. If you are contemplating a multiple zone flowing well, the Axelson specialist can install the correct cross-over now—and you won't have to pull tubing when you run the two-zone pump later!

Write the Special Products Department, Axelson Div. of U.S. Industries, 6160 S. Boyle Ave., Los Angeles 58, Calif.

SPECIAL NOTICE

For deep and/or high volume two-zone production Axelson announces a new special two-zone pump to run under a 26-ft. hydraulic pumping unit. Write for more information on this type of installation.

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Los Angeles 58, Calif.

- ☐ Two-Zone Pump
- ☐ High Volume Casing Pump
- ☐ Long Stroke 2-Zone Pump

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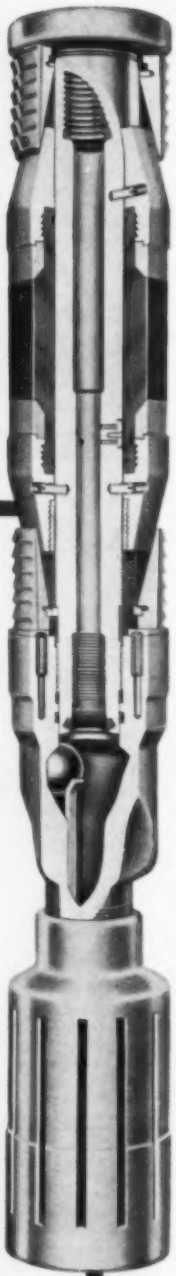
Reliable The Baker Cement Retainer almost invented the word



BAKER CEMENT RETAINER
PRODUCT 400

Important Facts About The Baker Cement Retainer

1. It is used for any squeeze cementing operation.
2. It is run on wire line, tubing or drill pipe.
3. Packoff is uniformly positive and dependable at either high or low pressure differentials. Opposed slips hold from either direction.
4. Ability to maintain packoff is independent of fluid pressure, or of set-down weight or tension.
5. A back-pressure valve automatically holds squeeze pressure against the formation. You can swab-test before bringing the back-pressure valve into operation.
6. The Baker Cement Retainer drills up easily and quickly. It's available in drillable, corrosion-resistant cast iron or in fast-drilling magnesium.
7. There's a full range of sizes and a family of accessories to help get the job done in the best way.
8. In some areas it is used as a bridge plug, too. It can be run as a plug—or converted to a plug simply by dropping a ball after its use as a Cement Retainer.

The Baker Cement Retainer outperforms almost anything we can say about it—and it's been doing it for years. It has presided over tens of thousands of high pressure squeeze operations with outstanding success.

Is it dependable at high pressures? It is. It has been set successfully at depths below 20,000 feet.

Does it set and pack off well at low pressures? It does. It has been set in thousands of shallow and medium depth wells.

THE BAKER SERVICEMAN looms large in this picture. He's the man who helps you extract all of the resolute dependability that's built into a Baker Cement Retainer.

When there's a question about whether you want a drillable squeeze packer or a retrievable one, talk it over with a Baker man. He's got the two most respected squeeze packers in the industry—the Baker Cement Retainer (drillable) and the Baker Full-Bore Cementer (retrievable).

A Baker man also has something else that's important. He's got skill. He's a specialist, a real professional, in squeeze-packer techniques.

BAKER
CEMENT RETAINER

BAKER OIL TOOLS, INC. HOUSTON / LOS ANGELES / NEW YORK

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

In the Holt-Bryant reservoir waterflood of the Delhi field . . .

SECONDARY WATER FILTRATION PAYS OFF

E. J. SIMMONS and LUTHER F. ELLISON,
Sun Oil Company, Delhi, Louisiana

FIG. 1. Secondary filtration unit was developed after considerable experimentation. Filter is cylindrical and equipped with a quick access closure on top.

PROPER EVALUATION and study of filtration requirements for specific water injection conditions can pay dividends. This was the case in the Holt-Bryant reservoir of the Delhi Unit in the Delhi Field of Louisiana, where Sun Oil Company is the operator.

Improved secondary filtration techniques devised through a joint effort of Sun's Production Service Laboratory and field personnel resulted in increased injection rates, eliminated drilling additional injection wells, cut well cleaning costs by an estimated $15,000 per year, and lowered basic filtration expenses by about $7500 annually.

It must be pointed out, however, that filtration methods used in the Delhi Unit were developed to overcome specific problems peculiar to this waterflood project and these results must not be accepted for general application. Over filtration as well as inadequate filtration can be costly and should be avoided.

Reservoir Background

The Delhi unit was legally established on February 1, 1953, with Sun Oil Company designated as unit operator of 257 wells within a unit area of about 12,000 acres, being approximately 12 miles in length and varying in width from less than one mile to more than two miles.

A primary aim of unitization was to allow the initiation of a repressuring and pressure maintenance program throughout the major productive zone, which is Cretaceous in age and locally named the Holt-Bryant sand. This reservoir is a stratigraphic trap which strikes essentially east-west, dips to the south and encompasses production that roughly coincides with the unit area, a long and relatively narrow confine.

As a result of reservoir configuration, a very limited natural water drive influences only the eastern extremity of the sand and supports an area which comprises less than 25 percent of the composite reserves. Top of the pay generally occurs between 3100 and 3500 ft and the section, although composed of stringers in several instances, is normally well-developed with gross sand thickness sometimes exceeding 100 ft.

As a whole, good continuity prevails and is enhanced by relatively high permeability, averaging approximately 1800 millidarcies throughout the pay. Considering secondary recovery measures, the Holt-Bryant reservoir appeared quite suitable for water-flood application.

Waterflood Program

With an ultimate plan for the line drive type of operation, large-scale salt water injection into the Holt-Bryant zone began during October, 1953. Fourteen injection sites, spaced approximately 1 mile apart across the 12 mile east-west expanse of the reservoir, were drilled or recompleted down-dip and well below the original oil-water contact to minimize the possibility of by-passing.

An integral high pressure (800-psi working pressure) distribution system, consisting of a main 6 in. line and laterals to the individual wells, was installed along the southern, down-dip flank of the sand with power originating from three properly spaced pump stations, each fully equipped with filtration and accumulator facilities.

Produced and extraneous salt water — compatible, relatively stable and unusually clean as a mixture — provide adequate supply to the three stations. The entire operational cycle is continuous and completely closed.

Pressure Differential

A sizeable east to west pressure differential existed within the pay when full-scale injection commenced, a condition which developed in reaction to prior years of competitive production practice with only localized and limited natural influx. Elimination of the cross-structure gradient was a fundamental purpose of the initial program and, to date, it has been significantly reduced. Simultaneously, the average bottomhole pressure of the formation has been appreciably increased.

The positive success of the overall plan at present is attributable to a closely controlled selective injection program which has been directed on a per-well basis.

FIG. 2. Quick access closure allows water to pass through disposable filtration cartridges before entering the well.

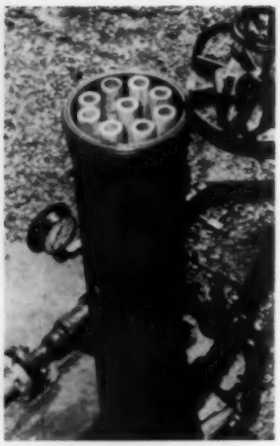


FIG. 3. With filter cartridges in place, in-coming water migrates through them into the perforated risers and is then directed to the well.

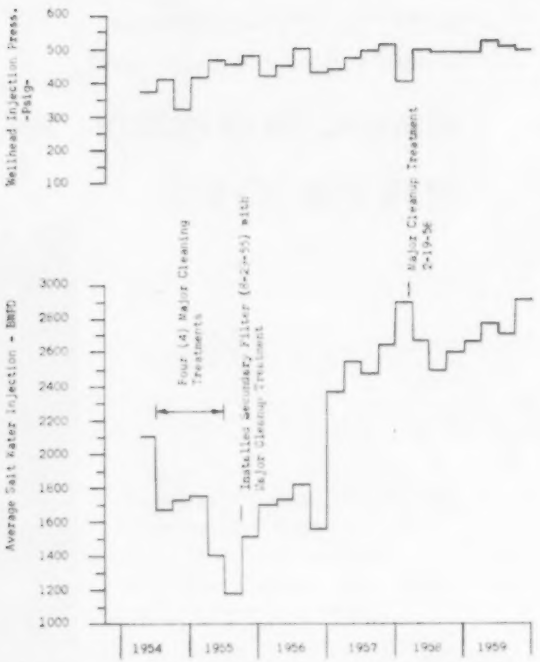


FIG. 4. Injection behavior of DU 3-3 is graphically portrayed from completion in early 1954 through 1959.

Minute Solids in Source Water

Inasmuch as the formation displayed excellent characteristics relative to water flooding, large scale injection into the Holt-Bryant reservoir was launched with confidence that the necessary line drive program, carefully controlled and highly selective, could be perpetuated by comparatively few injection wells without excessive operational expenditures.

Most wells temporarily possessed a very satisfactory injection capability after normal cleaning procedure — acidization with simultaneous backwashing. Nevertheless, this high capacity generally diminished very rapidly and it was soon evident that the rate of decline in injectivity would have to be substantially retarded in order to prevent unreasonable cleaning expense.

In addition, it was apparent that higher per-well rates specified for near-future operation would require several supplementary sites unless a means could be devised to sustain daily injection rates within the desirable range. Field and laboratory personnel then began a systematic and objective investigation of the operational network and soon discovered that the Holt-Bryant zone was highly sensitive to minute solids which were characteristic of the supply water and considerably smaller than the extraction size of the primary filters.

Evaluation Methods and Equipment Used

At that time, equipment now commonly available for the proper evaluation of raw water had not been introduced. Therefore, it was necessary for the laboratory personnel to develop their own methods in order to expedite a practical solution for the problem. It was felt that a knowledge of the amount and nature of the suspended solids was necessary to ascertain first whether the injectivity decline was due to primary plugging mechanisms such as carryover of suspended solids, or to secondary mechanisms such as precipitate formation or clay swelling.

Previous chemical analyses of the waters involved, and information on the character of the formation seemed to indicate that the secondary effects, if any existed at all, were minor. Side stream filters were used in an effort to obtain samples of suspended material large enough for quantitative analysis. At first, small commercially-available filters similar to automotive type oil filters were used. While these did trap quite a quantity of suspended material, it was impossible to remove the material quantitatively so that a meaningful analysis of the situation could be made.

After using several experimental filters consisting of fritted glass, sintered bronze, sintered stainless steel, and stainless steel wire mesh, quantitative samples with fairly reproducible compositions were eventually obtained. This reproducibility helped to corroborate the supposition that the suspended matter was actually being passed by the primary filters.

Even though the actual amount of suspended material per unit volume of water seemed low, it was felt that full size individual well head filters should be tried to see if trapping this foreign material would have any beneficial effect on the injection well reaction.

After considerable experimentation with commercially available vessels which were altered from time to time to fulfill specific needs, a secondary filtration unit as depicted in Fig. 1 was developed. The filter is cylindrical in shape, approximately 13 in. in diam and 43 in. high, and equipped with a quick access closure on the top, as reflected by both Fig. 2 and 3.

The interior is designed in such a manner that water must pass through disposable filtration cartridges prior to entry into the well. As shown by Fig. 2, each unit is equipped with nine elements (1.25 in. ID, 2.75 in. OD and 19 in. length) which surround 1 in. diam perforated risers within the vessel.

Incoming water migrates through the filtering cartridges, into the perforated risers and is then directed to the well, Fig. 2 and 3. The cartridges are composed of material which extracts solids or debris exceeding 25 microns in diam.

After a trial period on one well the efficacy of the filter in extending the period between cleanouts was clearly demonstrated, and the experimental program was broadened.

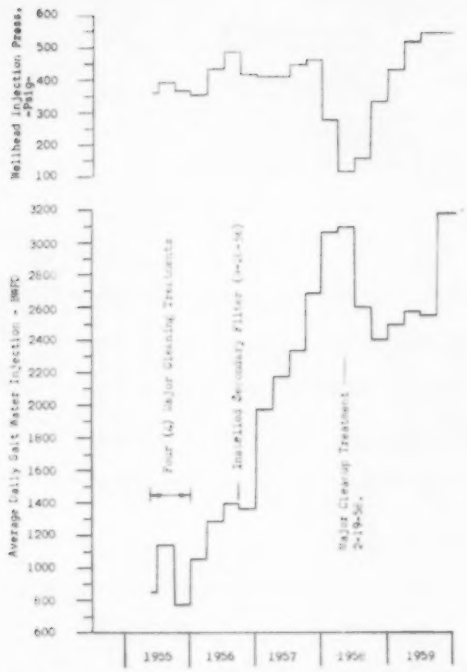


FIG. 5. Injection pattern of DU 3-6 IHB from its completion in 1955 through 1959 illustrates a surprising history. Injectivity deficiency was speeded by auxiliary filtration.

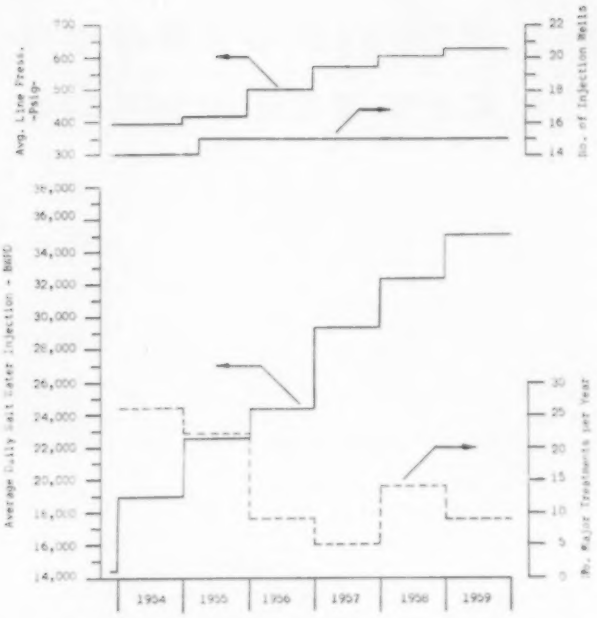


FIG. 6. Summary of injection performance of Holt-Bryant program from inception through 1959.

In most instances the secondary filter was placed near the injection well, directly upstream of a velocity type meter and downstream from a plug valve which is located in the lateral supply line. The valve is utilized to regulate the injection rate (Fig. 1).

Well Reaction

The first well of the Delhi unit to be equipped for experimentation with fullstream secondary filtration was DU 3-3 IHB. It was assumed that good permeability existed within the injection interval, for DU 3-3 IHB normally reflected an excellent initial reaction to cleaning.

Nevertheless, this high injection capacity usually declined very rapidly and would have demanded excessive cleaning expense to fulfill the desired minimum injection designation of that period, only 2000 bbl of water per day. In fact, detailed analysis of DU 3-3 IHB clearly stressed that a 2000 bbl of water per day assignment would involve an annual cleaning expense in excess of $8000 per year.

Unless secondary filtration improved and sustained injection capability, it was obvious that an additional injection well would be needed to satisfy the minimum requirements within this area of the reservoir and avert excessive cleaning costs. Since there were no suitable down-dip wells then available for conversion, a supplementary site would have necessitated the drilling of a new hole with the composite completion expense approaching $30,000. Fig. 4 graphically portrays the injection behavior of DU 3-3 IHB from completion in early 1954 through 1959. It should be noted that the secondary filter was placed into operation during August, 1955. Prior to this time, the well displayed a steadily declining injectivity despite several cleaning treatments and was capable of only limited injection rates, 1200 to 1400 bbl water per day with 300 to 400 psig wellhead pressure.

However, after secondary filtration this trend was arrested and the injection characteristics began to improve progressively without cleaning. As illustrated by Fig. 4, the degree of improvement seemingly derived from secondary filtration was very satisfactory; furthermore, the injection ability of the well has been sustained at an unusually high rate (2600 to 2800 bbl water per day at 450 psig pressure) during the last two years with only one cleaning treatment which was applied to prevent permanent bore damage rather than stimulate capacity.

The highly improved and sustained injectivity accomplished in the case of DU 3-3 IHB — which deferred a $30,000 supplementary well and virtually eliminated previously-required excessive cleaning expense — keynoted the operational and economic potential of refined filtration throughout the Delhi unit program.

During 1955 the pressure performance of the Holt-Bryant sand dictated a specific need for DU 3-6 IHB. Thus, the well was drilled in a critical location and completed to accomplish a minimum initial injection assignment of about 1800 bbl water per day.

Although the injection interval was well-developed and exhibited logging properties indicative of good permeability, the initial capacity of the well was very subnormal and inadequate with respect to relative performance.

Even with repeated acidization treatments, DU 3-6 IHB failed to respond satisfactorily. There was indication of extensive completion damage which appeared to be preventing proper cleanup of the injection zone. A fullstream secondary filter was installed adjacent to the wellhead on 9-20-56, in an endeavor to improve the deficient injection nature of DU 3-6 IHB.

Fig. 5 portrays the injection pattern of DU 3-6 IHB from its completion in 1955 through 1959 and illustrates a surprising history. The well clearly possessed only limited injectivity and was definitely incapable of accommodating its minimum injection requirement of 1800 bbl water per day before the installation of secondary filtration equipment.

Nonetheless, this deficiency was soon alleviated and DU 3-6 IHB has since become one of the most proficient injection wells of the entire net-

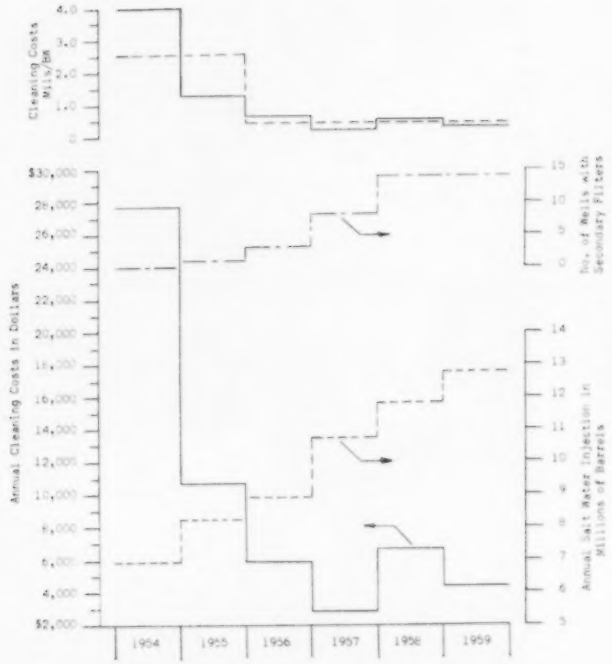


FIG. 7. Total yearly injection with respect to composite and per bbl cleaning costs are included in summary, as well as number of wells equipped with secondary filtration facilities.

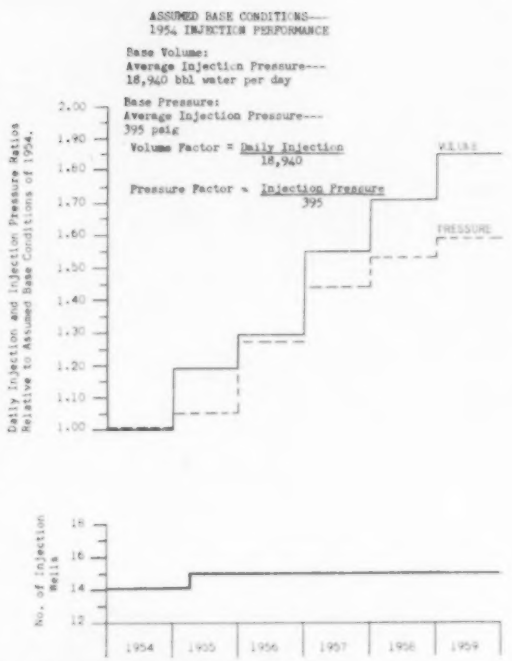


FIG. 8. Time to volume and pressure relationships of the injection program give a highly satisfactory reaction.

work, currently injecting 3500 bbl water per day with 500 psig pressure and incurring negligible cleaning expense.

Although there is a possibility that cleanup of the injection zone might have been effected over an extended period of time without auxiliary filtration, the fact that DU 3-6 IHB experienced unprecedented improvement and has continued to sustain exceptionally high injection characteristics without cleaning, strongly imply that secondary filtration prompted this success.

Fieldwide Reaction

After observing the positive results which apparently stemmed from secondary filtration in such instances as DU 3-3 IHB and DU 3-6 IHB, all remaining injection wells of the integral Holt-Bryant system were equipped with similar facilities as time and conditions allowed. Although per well response has been quite diversified, the general fieldwide reaction relates a highly satisfactory overall performance to date.

Fig. 6 and 7 summarize the injection performance of the Holt-Bryant program from the inception through 1959. Fig. 6 resolves average daily injection to pressure, number of major treatments per year, and number of injection wells, whereas, Fig. 7 includes total yearly injection with respect to composite and per barrel cleaning costs as well as number of wells equipped with secondary filtration facilities.

As illustrated by Fig. 6, the average daily injection capacity of the system has progressively increased in conjunction with reduced cleaning frequency. With 14 wells the average daily injection of 1954 approached only 19,000 bbl water per day and necessitated 27 cleaning treatments. In sharp contrast, fifteen injection outlets during 1959 accomplished an average of almost 35,000 bbl water per day yet entailed only 9 cleaning operations. The current rate approximates 40,000 bbl water per day with the same 15 wells, and there is no indication of appreciably altered cleaning frequency.

Fig. 7 presents a more definite measure of evaluation with respect to basic economics. During 1954, some 7,000,000 bbl of water were injected into the Holt-Bryant reservoir and required over $27,000 for associated cleaning costs. In comparison, injection in 1959 totaled approximately 13,000,000 bbl and involved only $4000 cleaning expense. Cleaning cost per barrel declined from 4 mils per bbl water in 1954 to 0.5 mils per bbl water at present, and it appears that 0.5 mils per bbl water may be 1.0 to 1.5 mils per bbl water less than an average value had improved injectivity not been accomplished. Assuming a net reduction of 1.0 mil per bbl water, the annual savings in cleaning costs affillated with the current rate of 40,000 bbl water per day amounts to almost $15,000 per year.

Other Benefits

It is not uncommon for water-flooding of a sand to experience a "fill-up" period in the initial injection history, during which time relatively large quantities of water can be injected with comparatively low wellhead pressure. However, after this time, injectivity usually diminishes as injection pressure ascends. Fig. 8 graphically resolves time to volume and pressure relationships of the Holt-Bryant injection program and depicts a highly satisfactory reaction. With respect to 1954, the volume of injected water throughout 1959 was increased almost 90 percent but required less than 60 percent increase in pressure. Inasmuch as most factors are adverse to this response — increasing bottomhole pressure of injection wells, increasing line losses due to higher velocities, roughness, etc. — the trend is exceptional and indicates a net reduction of power per bbl of injected water.

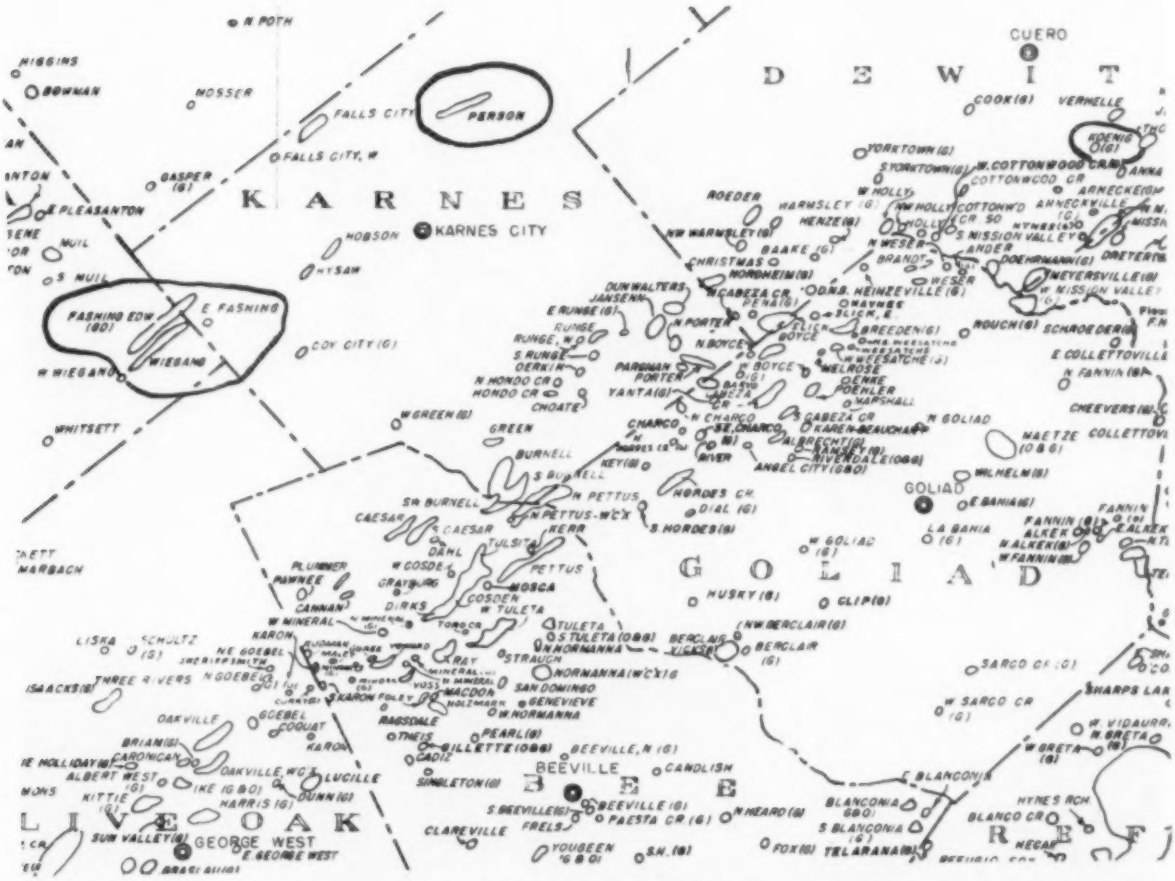
The extensive primary filtering system of the Delhi unit has been modified and refined considerably as result of secondary filtration. Down-time has been cut to such a degree that present facilities are capable of handling an additional 1500 to 2000 bbl water per day and basic filtration costs have been lowered some $7500 per year. ★ ★ ★

OPPORTUNITIES IN SOUTHWEST TEXAS

Operators shoot for a variety of structures that have established production potential . . . drilling continues at greater depths with increased emphasis on gas production. Drilling and geological experts discuss effective techniques

SOUTHWEST TEXAS continues to increase its emphasis on gas production as transmission and gathering lines are built, and most operators feel that there is much production promise at greater depths. In this established area, there remains substantial production waiting to be found through development work.

Several top geologists interviewed for this article gave the over all view for promising horizons throughout the region, furnished a comprehensive account of the active Person field in Karnes County, and the successful re-



Hot spots in Southwest Texas include Fashing field, a large Edwards formation gas trend near the older Wiegang field; Person field, a two-pay area in Upper and Lower Edwards formations; the Koenig field and surrounding area with multiple Lower Wilcox sands. Shallow production from previous years speckles entire area.

map courtesy Aztec Photocopy and Spotlight of Southwest Texas

sults of deep drilling in lower DeWitt County.

World's deepest ultra-slim hole, at 20,603 ft, was recently drilled by another company near Laredo in Webb County (The PETROLEUM ENGINEER, June, 1960).

Extensive shallow drilling program being conducted in marginal production and using new techniques for economic recovery is underway in Matador County and may prove useful in other areas.

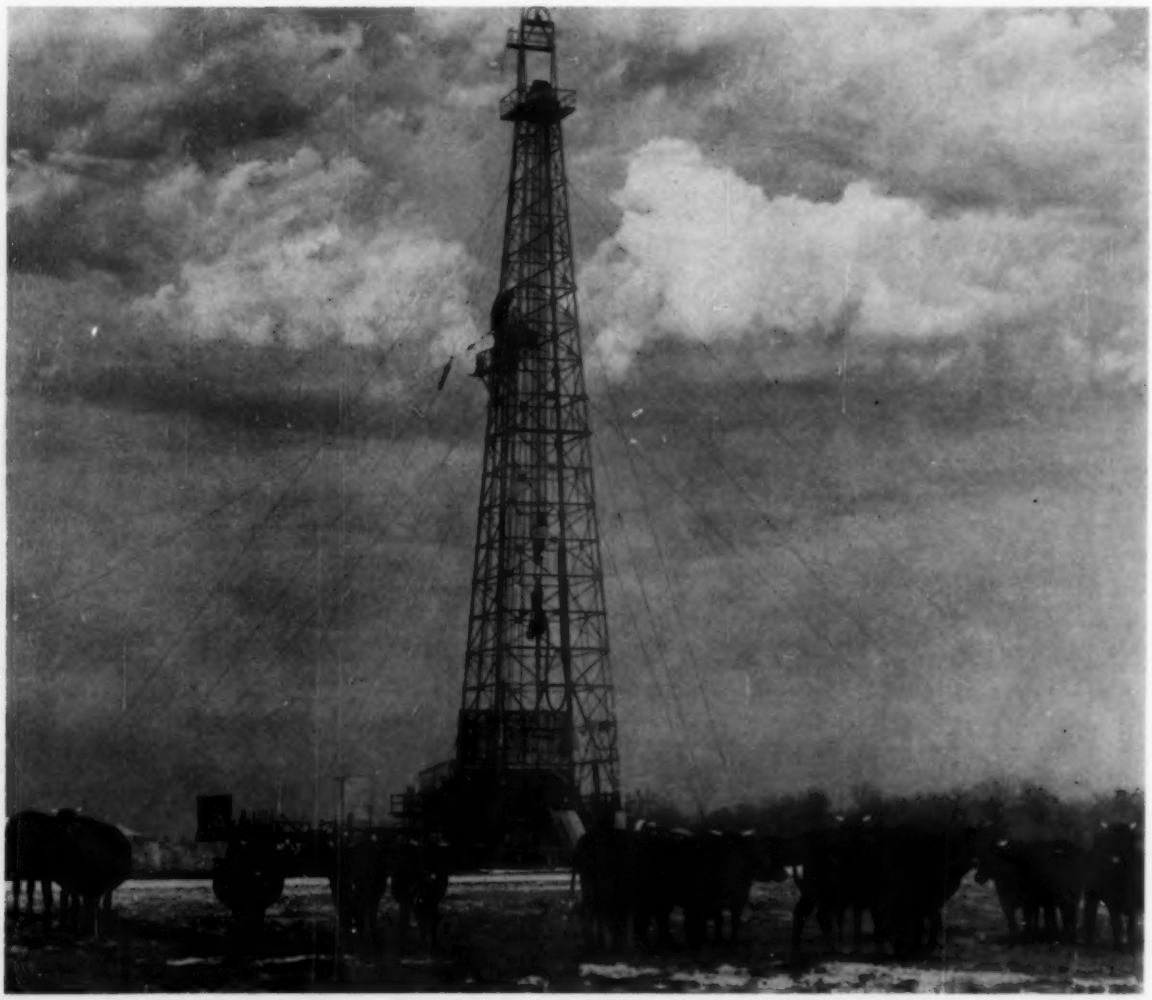
Gas sale stimulation . . . should come upon approval of the Federal Power Commission for building a 31-mile gathering system of 10, 12, and 14 in. pipe which will deliver 70,000,000 cu ft of gas daily to Tennessee Gas Transmission Company in Zim field, Starr County.

Gas pipelines will be operated by Natural Gas Gathering Company, a subsidiary of Delhi Taylor Oil Corporation, and Gulf Resources, Inc. will be a partner. Gas will flow from Juan Grande, Lopeno, Davey Crockett, and Northeast Lopeno fields in Zapata County, and El Puerto field in Starr County.

Exploration and Drilling

Rig activity . . . at the end of the first quarter of 1960, wildcats finding production were down 33 percent, but total wildcat activity was up 22 percent when compared with 1959, according to a scouting report from a major oil company.

Active rigs and pay strikes are compared in Table 1. Comparing the first quarters, total holes drilled were 403



Big ranch country in Southwest Texas causes drillers to take extra precautions . . . a sheet of paper blowing in the wind can spook a herd. Leases sometimes have clauses requiring asphalt roads to be built.

photos courtesy Humble Oil and Refining Company

TABLE 1. Rigs Running and Production in Southwest Texas.

First Quarter	Rigs Running	Oil Hits	Gas Hits	Dry Holes	Total Holes
1959	148	150	71	182	403
1960	154	136	81	202	419

in 1959 and 419 in 1960. There was an increase in rigs operating of 6 rigs, or 4.1 percent for the first 10 weeks of 1960 when compared with 1959, which mostly occurred in DeWitt and Karnes counties. Well completions during this period increased 16 wells or 4.0 percent.

Sacatosa field in Maverick County had an increase of 45 wells or 900 percent when compared with 1959. Continental Oil Company plans to complete about 200 wells in this field by the end of 1960.

Leasing . . . is generally down throughout the area. Northeast part of the Cretaceous trend has had the main increase in leasing for the region.

Geophysical exploration . . . has slightly increased since last year. In all there were 39 geophysical crews including 35 seismic, 3 gravity meter, and 1 other, searching in Southwest Texas during the first few months of 1960. Increase was attributed to activity in upper end of Wilcox trend.

Predicted completions for 1960, the scouting report estimated, should reach a total of 2938 wells. This reflects a decrease of 32 wells, or 1.2 percent, as compared with a total of 2973 wells drilled in 1959. This was attributed to the trend toward deeper drilling with active programs for deep Wilcox wells in DeWitt and Zapata counties.

Considerable decrease in leasing should occur, as the two previous years were exceptionally active. Scarcity of acreage in the southwest end of the Deep Wilcox trend helps account for this.

Estimate reflects an average of 42 geophysical crews per week active for remainder of the year, which stands at the same level as last year. Acreage acquired in 1959 that has not been evaluated should provide stimulus for this continued activity, report concluded, along with selected drilling. Majority of acreage is in the Wilcox and Cretaceous trends.

Promising Pay Horizons

There are frontiers in Southwest Texas that haven't been explored, and a major factor in evaluating the development and potential of the region is the expense involved in turning back substantial gas strikes due to lack of marketing facilities, a major oil company exploration manager said in recounting his extensive experience in Southwest Texas.

Referring to the Southwest Texas area, he said, **"I think it's one of the more promising oil provinces in Texas . . . . with such a variety of oil structures to shoot for and explore that I don't feel that the potential has nearly been reached."**

This country is very active, construction of gas lines should accelerate tremendously, and much gas production has been shut in. Along the Mirando shoreline there has been little market for gas production found. The Wilcox trend is being developed through Webb, Duval, Jim Hogg, and Zapata counties.

Area has been prominent for shallow oil wells, but the development of deeper wells has been held back until recently, and the area should be much more active in future years. In the lower country surrounding Kenedy County, a gas line has just been completed extending up the coast and furnishing fuel for industries around the Houston area. Gas is also being taken from fields in the Lower Rio Grande Valley.

Production in Starr, Cameron, Hidalgo, Willacy, and Brooks counties is Miocene-Frio and some Vicksburg. Those horizons are particularly productive, and "haven't been wrung out, the exploration manager commented.

Another province, called the Edwards lime trend, has given extensive gas production. Trend starts in Northern Webb County at the Rio Grande and extends northeast through LaSalle, North McMullen, and Atascosa counties.

"I wonder if it isn't a mistake stopping at the Edwards," he mused, "since there's no reason to believe that there isn't porosity in other limes below. The new frontiers are in depth." Lower Frio sands have been the main objective in previous years, providing gas and gas distillate, which can be produced 30 days per month.

Possible formations to look for are the Glen Rose, Sligo, and Hosston, the three principal ones to check into before going deeper. The Wilcox extends through Karnes, Wilson, and Gonzales counties, and has been providing good plays recently in the deeper zones. Further west, from Bexar County, harder rock and shallower horizons are encountered — Escondido sands, Olmos, and San Miquel, which are relatively shallower depending upon where they are found.

In drilling, walnut hulls have been found to be effective in shutting off pressure-loss formations, and have proved better than sand in fraccing, also. Sluffing shale can be fought by getting the mud in shape before entering a shale section if its presence is known, or setting protective strings.

Person Field Potential

Development of the active Person field in Karnes County was initiated by a Brazos Oil and Gas Company discovery that has resulted in several other producers with prospects for many more.

A recent Sligo test to the field indicates that the field may be productive on both sides of the fault. Production has been established on the upthrow to the South, and shale on the downthrow now also looks productive.

Person field is located in north central Karnes County, Texas, as shown on **Map 1.** It is about 25 miles east of and slightly north of the Fashing field and Atascosa County. Field was discovered by the Brazos No. 1 Person, which found Edwards limestone hydrocarbon accumulation.

What can be expected for the field is forecast by Alan Reagan, exploration geologist for Brazos. There is possible structural closure on the upthrown South side of the normal north-dipping strike fault, Reagan said. It is believed that the fault provides updip limits of the Person field by causing porous and permeable Edwards lime to be uplifted and sealed against the overlying and relatively dense Georgetown limestone. Limits of the field appear to have a present north-east-southwest extent of about one mile.

Person field included 11 wells completed by the end of the first quarter of 1960. The field is a two-pay area in Upper and Lower Edwards limestone formations. Earlier shallow Wilcox production had been established at about 1200 ft and less.

Edwards limestone is a crystalling limestone, with porosity in the Persons field. Producing section consists of the upper 200 to 350 ft of Edwards lime. It is characterized by streaks of porous limestone with considerable fracturing and vugular to intergranular porosity separated by section of hard, dense limestone with no measurable porosity or permeablility.

Three productive sections Brazos tested in the No. 1 Otho D. Persons had average porosities of 11 to 13 percent and overage permeabilities of 11 to 12 millidarcies. Obviously the rates of flow from the sections were too high to be attributed to the visible porosity and permeability.

It is therefore concluded that the

vugular porosity may be so connected by fractures as to provide zones with excellent productive characteristics, Reagan said. **"It is hoped that further coring and testing in the field will aid in solving this apparent paradox."**

Oil produced in the Person field is 38 deg to 39 deg API gravity sour crude with a fairly high paraffin content. Trucking serves as the only oil outlet in the field.

A definite gas cap has been established at about 200 ft thickness, and the oil column has a thickness of 100 to 150 ft. No estimate has been made of the lateral extent of either. It is not known whether the Edwards limestone section in the Persons field is one reservoir or is broken up into several zones by the streaks of dense lime which are readily traceable over the field.

Shell, with completion of the No. 1 Dugie, requested a discovery allowable for the lower Edwards zone, and application is pending with the Texas Railroad Commission. Discovery is significant principally because of the proved presence of oil accumulation in commercial quantities in the down-dip portion of the Edwards trend. It is hoped that exploration for similar production is encouraged along other portions of the trend.

Exploration for lower Cretaceous reservoirs may also be encouraged by this discovery. There is no reason to believe that similar accumulation cannot be found in the Glen Rose and Travis Peak formations of the Trinity group, provided that sufficient porosity and permeability are present.

"I do not know what we can expect in the way of recoveries from the reservoir," Reagan said. **"Much will be learned in coming months as bottom-hole pressures and producing rates are observed."** An unanswered question is the spacing pattern which will develop in the field, and how densely wells can be drilled to drain the reservoir and yet stay on a sound economic basis.

Lower Wilcox Finds Dispell Old Belief

"New finds in the Lower Wilcox, which extends through DeWitt and Karnes counties, have dispelled the belief that if a strike isn't made in Upper Wilcox you won't hit in Lower Wilcox either," Art Dickinson, geologist for Lion Oil Company, commented in reviewing activity.

Lion has completed two wells in the area. The No. 1 Belitz has over 150 ft of pay in multiple Lower Wilcox sands between Yorktown and Cuero at a total depth of 10,517 ft. Production is found from 9200 to 9900 ft. The No. 1 Alfred Gerbert gas unit also produces at the same depths. The field may eventually contain six wells on 320 acre spacing.

Other discoveries adding significantly to the Wilcox find is the Lone Star Producing Company hit at Koenig field and the Argo Oil Corporation No. 1 Cook. A deep well also exploring for the same deeper Wilcox section is the No. 2 August Duderstadt jointly operated by Harkins and Company, George Musselman, and Gulf Oil Corporation.

"There is a problem of producing gas from formations with relatively low permeability and high interstitial connate water. This is demonstrated by the Belitz well and others which have 30 millidarcy permeability and high interstitial water content. **The trend, which is not localized, is pointed up as an important deep trend going into adjacent counties, even into Lavaca County in the Southwest Speaks area."**

Deepest wildcat to be drilled in the trend has been approved by the state regulatory agency and is projected to 14,500 ft in Matagorado County. The operator hopes to find production in the Basal Frio section.

"It's encouraging to find what appears to be substantial reserves in deeper Wilcox formations," Dickinson commented. **"There should be a pick-up in activity."**

Operating hazards include sizable rattlers which collect in dens and sometimes must be burned out from drill sites. Strike first, rattle later tendency of the snake has created fleet-footedness among drilling crewmen.

Optimum Drilling Technique

In some operations we've been so free of drilling problems that we haven't even needed a toolpusher on the rig. In the La Blanca area, where we encounter 6000 to 7000 psi wellhead pressure, we set casing above the high pressure zone, Mathew B. Gordy, division superintendent, said.

We use an optimum drilling program with the lightest mud weight possible; maintain desired hydraulics, annular velocities, and jet velocities to conform with good drilling practice; use proper bit selection and speed for maximum efficiency. Eighteen drill collars are used with 5000 to 6000 psi of bit weight.

In our contracts we use a clause that on any well exceeding a maximum of 72 hours of lost circulation, the company takes over operation of the well. Anything above 12.5 lb mud weight we consider abnormal, and also undrillable formations where only 10 or 12 ft per day can be made.

We don't take over when shifting shale causes drilling slower or twists the pipe off and necessitates a fishing job. In the lime trends we can't use an open-hole test. We have to case, acidize, fracture and produce for a while until the well draws down to its true flow.

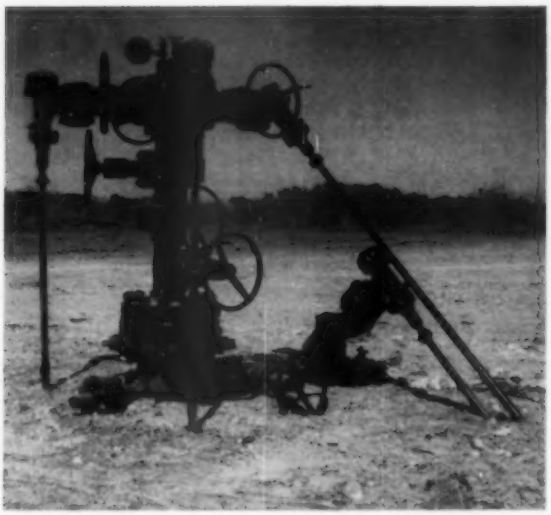
Using slim-hole techniques, we have taken old wells and deepened them 2000 ft into other sands, getting an encouraging peneration rate as compared with normal-size holes. Economics of the slim-hole technique determine whether to condemn or develop the well further.

Hottest part of the deep Edwards trend extends through Karnes, Atascosa, McMullen, and LaSalle counties.

Large-Scale Drilling In Marginal Zone

Most unusual oil development in the region, Sacatosa field on the Chittim Ranch in Maverick County, holds interest as a large-scale attempt to produce profitably from a marginal production zone. With 72 wells drilled this year, and a projected total of about 200 wells by the end of the year, Continental Oil Company has devised a special drilling and completing process to put the low permeability field on a paying basis.

In its San Miguel producing formation, the shallow sands are hard and tight, and won't give up much fluid. Conoco sets a small string consisting of a single pipe, without setting surface casing, and then uses a specially-de-



Increased use of quadruple completions, such as this well with three strings of tubing and a fourth flowing through the annulus, have saved on completion costs. Wider spacing, economy in drilling also cut operating expenses.

Production extends into the particularly active Valley area, which has the deepest well, continuing pay strikes with emphasis on gas production as proposed lines will collect gas from several fields.

vised fracturing process to stimulate production.

Wells that formerly would have produced less than 5 bbl per day can now flow at a 50 to 100 bbl per day rate. Field produces from a pay section averaging slightly more than 20 ft thick and wells are 1400 to 1600 ft deep.

Giant computer helped determine the most economical completion method. This method consists of drilling through the pay formation, setting pipe, and perforating the pipe opposite the producing formation. About 60,000 gal of crude oil, 90,000 lb of sand, and a special fracturing fluid are pumped down the pipe and through the perforations to fracture the formation.

Wells cost about $15,000 to drill and complete plus $4000 for fracturing. Costs balanced against production results, Conoco representatives say, make the technique economically sound.

Active Drilling Programs

Shell Oil Company. One of the most active companies in this area, Shell has also drilled the second deepest well. The Carroll I in the Brushy Creek area was brought to a total depth of 19,765 ft and plugged back to 11,205 ft. It was perforated at that depth and the test produced about 5,000,000 cu ft daily through an 11 15/64 in. choke. Well made 16 bbl condensate per MMcfd, and is a Wilcox completion.

Other operations since the first of the year include a deep Vicksburg test projected to 17,000 ft at McAllen Ranch in Hidalgo County; a Deep Vicksburg dry hole at Javelina field in Hidalgo County; and two other producers at North Rincon, both in the 9000 to 10,000 ft range.

In Cameron County, three wells were drilled. One was a 15,000 ft Upper Frio test, two others were 7000 ft Miocene tests, and all revealed no commercial production. Three rigs were drilling to the Edwards at 11,000 ft, and a 14,000 ft exploratory test was underway at the Persons field in Karnes County.

Shell keeps five contractor's rigs and one company rig, limited to 10,000 ft depths, busy in Southwest Texas. They operate on a standard footage contract, and go on a day rate under unusual conditions when the company wants direct supervision of the well.

Problems encountered in the area are extreme high pressures, and a tendency for lost circulation. This is combatted by setting a protective string at 7000 to 7500 ft in deep wells and using it to pull the drill string up while mud is made heavier. Drilling operations are continuing at an accelerated pace over previous years.

Atlantic Refining Company. Atlantic has played the Wilcox in McMullen, Live Oak, Duval, Zapata and Jim Hogg counties, James Wilson, exploration manager for the region, said "There's more country that hasn't been combed over in Wilcox formations."

The Wilcox consistently has sands through the Karnes County district, and Atlantic has acquired an interest and probably will drill a test by August, Wilson said. Abnormal pressures have been encountered on top of the Wilcox, and production strings were set with heavy mud. Sand and shales encountered won't stand over a 12 lb weight mud.

Production string is sometimes set high, and because of shale gas a liner is run for completion of the well. Some sidewall cores are taken, and electrical log interpretations are made. Low-lime oil emulsion muds are used, since gyp-base muds didn't give too satisfactory results, Wilson said. Diamond bits are being tried, even in shale.

"Gas has been a god-send," Wilson said, **and demand "should be fairly healthy. It's mediocre oil country, but good gas country."** Atlantic's drilling operations this year include five gas wells completed. Three are in Wilcox formations with one in Hogg County flowing 76 million cu ft per day on open flow test; one is in Queen City formation; and one Frio strike was made in the Tabasco field. In Hidalgo County, Atlantic is drilling in Frio and Vicksburg sands. Slim-hole drilling is being used in normal pressure sands, setting 4½ in. casing to 8000 ft.

Tennessee Gas and Oil Company. We plan to continue exploration and development in Southwest Texas on a normal budget, Wilton E. Scott, senior vice president, stated. It still looks good, although it is not an area of unusual plays at this time. There's production being found now in the deeper sands, he said.

Tennessee Gas wells drilled during the first quarter in Southwest Texas include five gas wells, two in Karnes County, two in Jackson County, and one in Calhoun County. Net daily average of established production for the

first quarter was 1631 bbl of oil and condensate, and 54,319 Mcf of natural gas at 14.65 psi.

Contractors Views On Drilling Conditions

Buzzini Drilling Company. There's a tendency toward continually deeper drilling, Arthur Buzzini, secretary-treasurer, commented. **"Southwest Texas has been good for 40 years and should continue to be . . . we haven't yet reached the depth that we can't find hydrocarbons."** Although some deep pay zones found may not prove to be economical. The good shallow sands were discovered first and we're now in the fringes of known horizons.

Edwards leasing extends into Gonzales and Fayette counties, Buzzini said, and also down to LaSalle and McMullen and into Webb counties. Development drilling continues in the coastal counties as usual.

Average drilling consists of hard digging, high gas pressures, and hole deviation troubles. Mud control must be maintained, Buzzini said, and usually two ram-type and one annulus-type blowout preventer contain pressures encountered.

Field Drilling Company. "There are three types of drilling encountered . . . easy drilling, Edwards trend drilling, and harder drilling in the western part of South Texas near Laredo, in Webb and Zapata counties," commented W. Earl Rowe, president, a veteran of 26 years as an operator and contractor in South Texas.

Coastal drilling to depths of 9000 to 10,000 ft is relatively easy digging, he said. In certain areas protective casing is necessary due to the high pressures encountered. "If you get the mud heavy, low pressure upper sands will break down and lost circulation may occur, thus subjecting the well to blowing out. In this area, we need experienced drillers and good, smart mud men."

Reserve mud aids operations, and mud companies keep records of wells drilled in particular areas that aid in drilling a well.

"Drilling here is 99 percent conventional," Rowe said, **"to a certain depth drilling is fairly constant, and the trend in old structures is to deeper wells where hazardous conditions are often encountered. Contractors need good manpower and equipment, and even at best you hit areas with very abnormal pressure that is difficult to control,"** he said.

Commenting on his experience in securing production, Rowe said that in the Frio and Vicksburg formations, lenticular sands pinch out, creating stratagraphic traps. The Edwards and Wilcox formations are fairly constant, Rowe said. These formation blanket some areas, though they are not uniform. Driller must catch the structure, as well as find the lime or sand porous. "These are hazardous," Rowe said.

As a general average, 1 out of 10 makes a discovery, he estimated, and one discovery out of 20 makes a good commercial area where 20 or 30 good wells can be produced. Some areas in South Texas are rich in reserves, Rowe observed, "and good sands found here give up more per acre foot than a limestone formation. For instance, 10 ft of good Frio sand may produce as much as 50 ft of of lime in West Texas.

Field Drilling has remained active in South Texas drilling for both major oil companies and independents. Rowe expects drilling activity in the area to continue in the tempo of the past 26 years, no boom, just methodical drilling. He anticipates especially increased exploration for gas.

Rowe pointed out also that it's not as expensive to drill in South Texas as in some areas. Normally, drillers can move over terrain without building roads. Along the coast for 50 miles inland, mostly black land or sandy loam forms the topsoil, and with the normal rainfall moving is no problem. Farther back from the coast the terrain rises with a gradual incline and is mostly rolling hills. This minimizes the cost of moving heavy mud equipment.

Southland Drilling Company. "Drilling in this area requires particularly good blowout preventers and high pressure pumps," Edward P. Copenhaver, partner in the company, commented. **"We're running more and more drill collars, also."**

Unusual operation undertaken by Southland consists of drilling with one rig just below the Mexican border near Reynosa and McAllen, where the Mexican national labor union requires a crew of 28 men for the operation. Tests on formations have yielded fair production thus far.

Fitzpatrick Drilling Company. The tendency is toward deeper drilling from 9000 to 12,000 ft, in Lower South Texas, W. S. Fitzpatrick, vice president and general manager said. Wildcats are being drilled in Hidalgo, Cameron, and Kenedy counties.

In Hidalgo County fields, many of the wells are being brought in as triple completions.

Abnormal pressures are frequently encountered, he said, and we feel that the best insurance against that condition and other problems, such as lost circulation and salt water flows, is the setting of intermediate string on the deeper wells.

Normally, three blowout preventers are used, and many operating companies require an independent high pressure preventer or accumulator to close them quicker and faster. Oil emulsion mud has greatly improved rate of penetration and drilling efficiency, Fitzpatrick said.

Clark Drilling Company. "Wider spacing is being used in Southwest Texas, which allows you to pay more attention to economics," Dan Clark, president, said.

We generally make 40 to 60 percent more footage per day using the new-style nozzle bits which removes abrasive material, and aids in reducing temperature. In this area a typical well temperature is 200 deg at 9500 ft. If an operator doesn't reach 3600 ft on the second day under surface pipe, he knows something is wrong.

"An advantage of staying in Southwest Texas, though, is that the contractor doesn't have as many long rig moves between jobs."

Clark anticipates more activity in the Rio Grande Valley, Karnes County, and Atascosa County. "Future drilling activity looks as well as last year, but there's nothing to indicate any more."

Hunt Drilling Company. "In most areas of Southwest Texas there is fast drilling," Walter Kalteyer, vice president and general manager, said. "There are some areas that have hard drilling, however, such as Mullins, Atascosa, and Karnes counties. In Taft and San Patricio counties, diamond bits are used."

With the allowable cut, operators are pinched and they are asking more of the contractor, Kalteyer said, but they can't give it. Contract time has already been reduced 48 percent with jet bits and high pressure hydraulics.

On turnkey contracts, Kalteyer commented, operators pay a premium to the contractor for assuming all of the risks, even though the operator is better equipped to insure against possible loss himself. Turnkey contracts are being used in Southwest Texas, but as yet they haven't become prevalent.

Drilling techniques involve using mud weights to keep well under control. When an excess of 5000 lb pressure is encountered at the surface, surface string is set, preventing loss of heavy mud to low pressure formations up the hole. Not much air drilling is used due to water seepage in the area.

Kalteyer felt that opportunities for discoveries were particularly good in the Valley, around Hidalgo County. He also felt that the Persons field in Karnes County would live up to expectations.

* * *

In Western Oklahoma

SONIC LOG EVALUATES MORROW SAND

FRANK S. MILLARD *Carter Division*
Humble Oil & Refining Company, Tulsa, Oklahoma

EMPIRICAL CURVES which relate weighted core porosity and formation velocity or transit time have been developed for the relatively shale-free Morrow sand in western Oklahoma. The effect of fluid and residual gas in the invaded zone has been investigated and is considered in the empirical curves.

The comparison of formation resistivity and transit time using specially-designed graph paper in many instances provides a rapid method of formation evaluation. Some examples showing the application, advantages and limitations of the procedure are presented.

Sonic Logging Increases

Sonic logs are becoming increasingly more interesting in formation evaluation because of the relationship which exists between the measured velocity or transit time and the formation porosity.

Empirical studies of the Morrow sand have shown that Wyllie's time average equation[1] is reasonably accurate for porosity resolution. Some difficulties are encountered in the case of gas bearing sands and the response to the residual gas in the pore space of the invaded sand must be taken into consideration. The presence of residual gas in the invaded zone apparently increases the transit time as opposed to a fluid-filled condition for any given porosity value.

To facilitate the qualitative interpretation of the Morrow sand, special graph paper is used which permits the

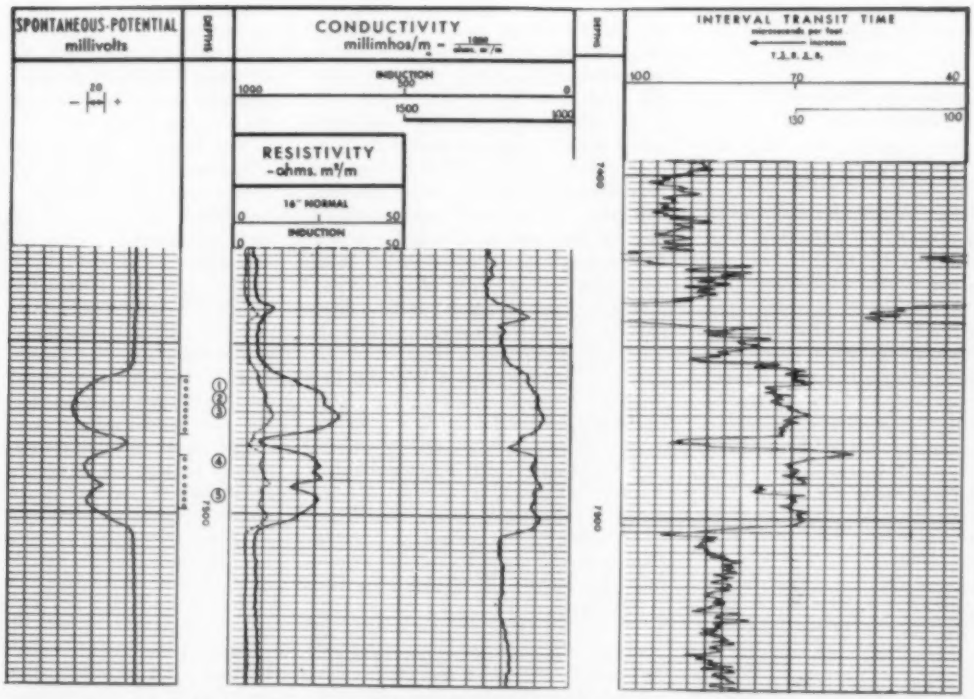


FIG. 1. Induction electric log and sonic log evaluated the Basal Morrow sand from 7460 to 7504 ft in Beaver County, Oklahoma. Mud resistivity was 0.74 ohm meter at 135 F. Cores were cut from 7470 to 7508 ft and analyzed. Core porosity was then correlated with sonic log and linear plot made of transit time and weighted core porosity.

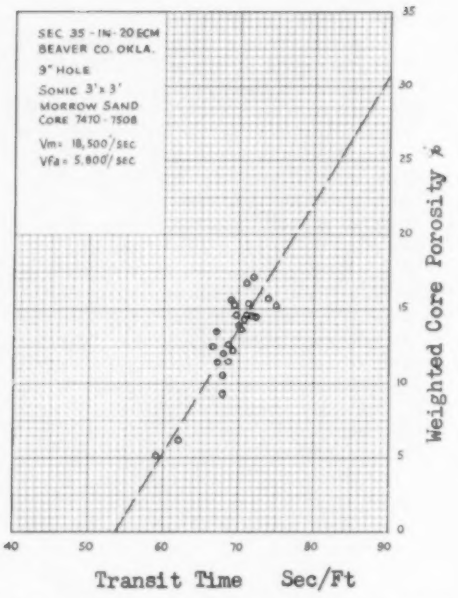


FIG. 2. Plot shown is a verification of Wyllie time average equation. Extrapolation of curve to zero porosity established a matrix velocity of 18,500 ft per sec and a calculated apparent fluid velocity of 5800 ft per sec.

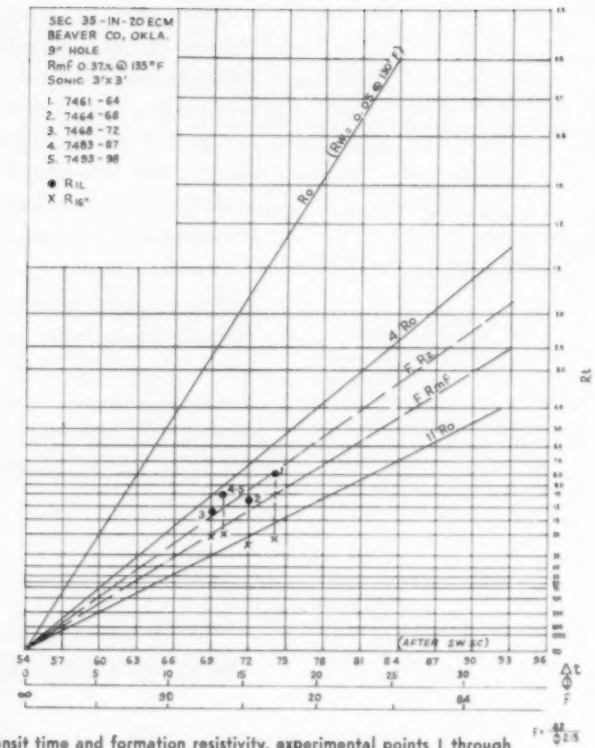


FIG. 3. In plotting transit time and formation resistivity, experimental points 1 through 5, from 7461 to 7498 ft were placed on this special graph paper and they fell within the range of 4 Ro to 11 Ro. The sand was therefore interpreted to be oil productive.

comparison of the formation transit time and true formation resistivity.[2,3] In many instances, this comparison will permit the recognition of gas, oil, or water bearing formations.

Graph Compares Transit Time and Resistivity

Special graph paper has been so constructed that the transit time and correlated porosity is scaled as a linear on the abscissa. In addition, the formation factor is scaled as a function of a linear porosity scale on the ordinate. The graph paper used in this article is based on the Humble equation[4] for sandstones, where $F = .62/\phi^{2.15}$.

According to Archie's equation[5] $Ro = FRw = Rw \times 0.62/\phi^{2.15}$. Therefore, for clean sands, Ro is directly proportional to the formation factor and inversely proportional to the porosity. As a result of this relationship and graph paper design, a plot of the resistivity of the water bearing sands versus the transit time will establish a straight line on the chart.

The slope of the line which represents the water-bearing condition will be dependent upon the formation water resistivity, and therefore, only sands containing the same formation water should be compared on the same graph. When water-bearing sands are present, a plot of the corresponding transit time and true resistivity will provide the Ro line. If it is suspicioned that the sands in question contain oil or gas, Rw must be obtained from other knowledge of the formation water or computed from the self-potential curve.

An estimate of the true resistivities of the zones of interest are established, then these values are plotted versus the corresponding transit time on the special graph paper. Deviation downward and to the right of the Ro line will permit the detection of oil or gas bearing zones.

When using this procedure in field practice, it is advantageous to include lines which represent ratios of 4 Ro and 11 Ro. In a general way this has provided a means of separating potential water, oil, or gas producing zones. Water-producing sands fall in the Ro to 4 Ro range, oil sands in the 4 Ro to 11 Ro range and gas sands usually exceed 11 Ro.

To further facilitate this interpretation, a corrected 16 in. normal should be plotted versus the transit time. This is considered necessary in order to have a better understanding of the effect of invasion which occurs in the sand and to properly recognize the presence of oil and gas in the invaded zones.

The short normal points may be compared with the assumed total invaded condition which can be represented by a line on the graph paper equal to FRmf. From experience gained with the 16 in. normal in the study of the Morrow sand, it has been found that fluid composed of formation water and mud filtrate must be considered for the invaded zone.

The ratio of the formation water to the total water in the invaded zone (z) is thought to be 0.075 to 0.1. Rz represents the resistivity of this fluid and its value[6] is obtained from the equation;

$$Rz/Rw = \frac{Rmf/Rw}{(1-z) + z\,Rmf/Rw}.$$

A line equal to FRz should therefore be placed on the graph paper for comparison purposes because theoretically, for any water-bearing sand the corrected short normal-transit time plot should fall on this line.

Additional interesting information can be obtained by plotting Rxo values obtained from microsurveys[6,7] versus the corresponding transit time. These data should, however, be compared with the line plotted on the graph paper representing FRmf. Rxo values plotted vs the transit time for water-bearing sands should fall on or near this line. If the sands contain residual oil or gas, the points should plot below and to the right of the FRmf line and

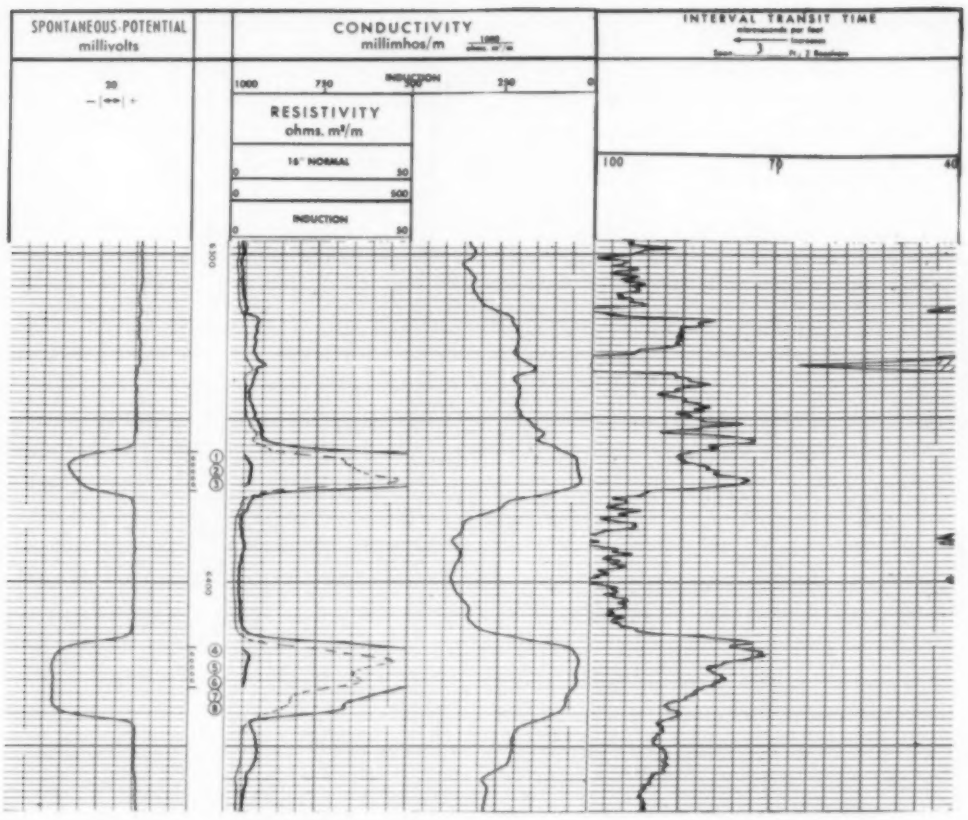


FIG. 4. Induction electric log and sonic log were run on Morrow sands in Texas County, Oklahoma. Mud resistivity was 1.6 ohm meters at 118 F. The sand was cored from 6417 to 6439 ft and analyzed.

thus permit an additional means of detecting oil or gas bearing sands. The deviation from the FRmf line could also provide an estimate of the residual oil in the flushed zone.

Logging in Western Oklahoma

Logging procedures in Western Oklahoma vary considerably with the operator and mud conditions encountered in the area. Generally muds are in the range of 0.5 to 2.0 ohm meters at bottom-hole temperature, therefore, fresh mud logging techniques are usually used. Electric logs, induction electric logs, microsurveys, velocity logs and occasionally laterologs or guard logs are used for formation evaluation purposes and for correlation. The field examples presented will primarily concern the use of the sonic log and the induction electric log as a means of evaluating the Morrow sands. It should be pointed out that the electric log, laterolog or guard log could also be used in conjunction with the sonic log in much the same manner.

Field Examples

Fig. 1 includes a portion of the logs recorded in a well in Section 35-1N-20ECM, Beaver County, Oklahoma. Mud resistivity was 0.74 ohm meter at 135 F bottom-hole temperature. An induction electric log and sonic log were run for the purpose of evaluating the Basal Morrow sand which occurs from 7460 to 7504 ft.

Cores were cut from 7470 to 7508 ft and analyzed. The core porosity was then correlated with the sonic log and a linear plot made of the transit time and weighted core porosity. This plot shown on Fig. 2 is a verification of the Wyllie time average equation. Extrapolation of the curve to zero porosity established a matrix velocity of 18,500 ft per sec and a calculated apparent fluid velocity of 5800 ft per sec.

Experimental points 1 through 5, from 7461 to 7498 ft, were plotted on the special graph paper (Fig. 3) and they fell within the range of 4 Ro to11 Ro. The sand was therefore interpreted to be oil productive. A plot of the corrected 16 in. normal also indicated the presence of hydrocarbons. The well was perforated from 7460 to 7477 ft and 7483 to 7489 ft. After a treatment of 500 gal of mud acid with a fracture job of 8000 gal of lease crude and 8000

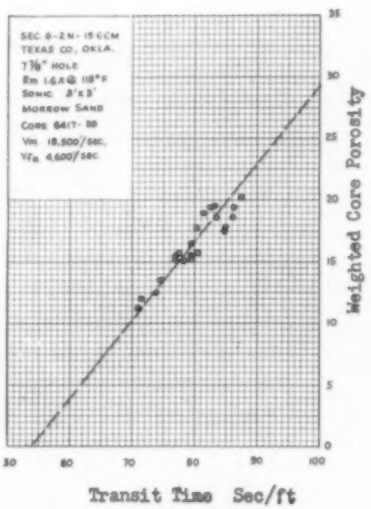


FIG. 5. Weighted core porosity, compared with transit time, established the matrix velocity as 18,500 ft per sec, and the apparent fluid velocity calculated by Wyllie formula was 4600 ft per sec.

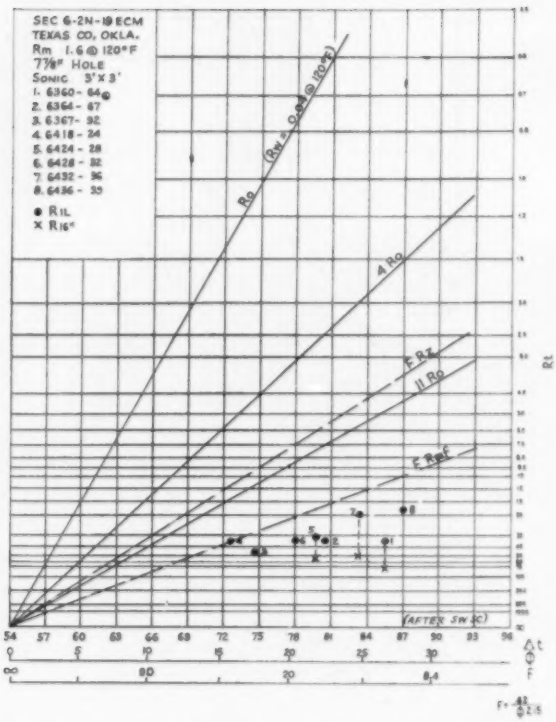


FIG. 6. Further evaluation of Morrow sand, using special graph paper, shows that experimental points 1 through 8—from 6370 to 6392 and 6418 to 6439 ft—fall substantially below the 11 Ro line, and therefore the sand was interpreted to be gas productive.

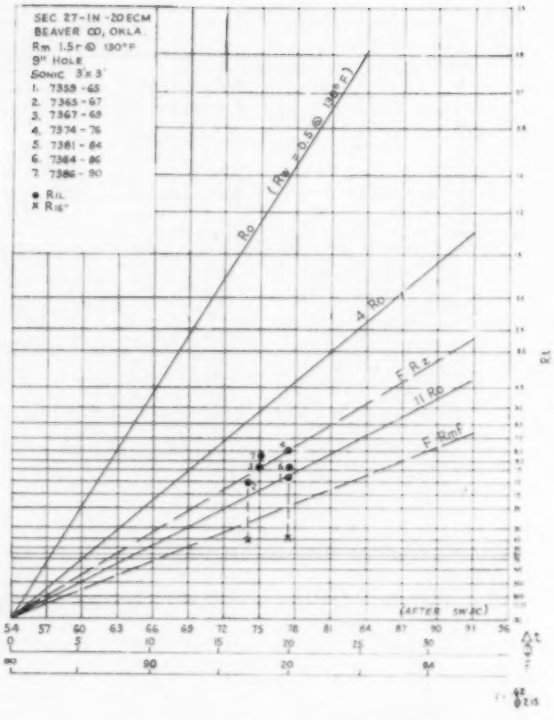


FIG. 8. A plot of transit time and formation resistivity for experimental points 1 through 7, from 7359 to 7390 ft was made using the special graph paper. Experimental points fall between 4 Ro and 11 Ro. Sand was interpreted to be primarily oil productive.

lb of water-wet sand, the well flowed through 2 in. tubing at an initial rate of 486 bbl per day.

Fig. 4 includes the logs of the Morrow sands of a well in Section 6-2N-9ECM, Texas County. The induction electric log and sonic log were run. Mud resistivity was 1.6 ohm meters at 118 F bottom-hole temperature. The sand was cored from 6417 to 6439 ft and analyzed. Weighted core porosity was compared with the transit time as

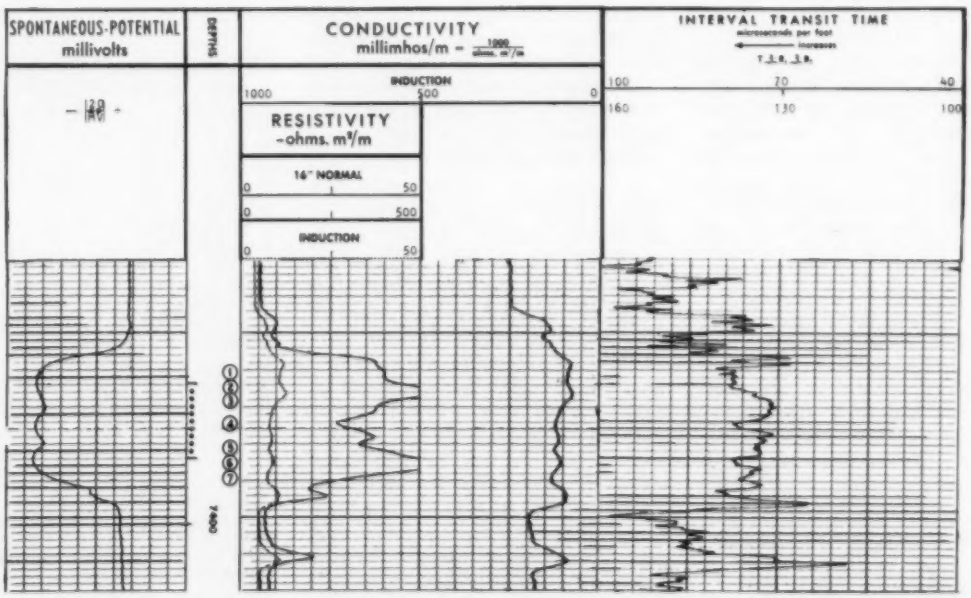


FIG. 7. Portion of induction electric log and sonic log for Upper Morrow sand in Beaver County, Oklahoma, shows that mud resistivity was 1.5 ohm meters at 130 F bottom-hole temperature.

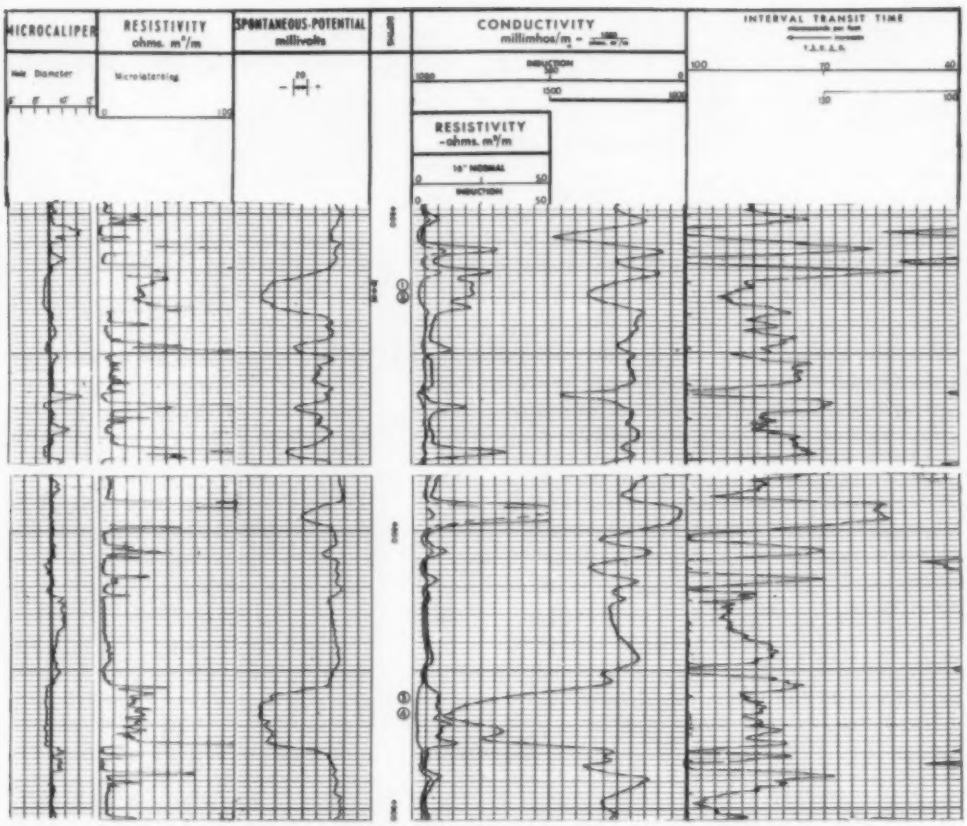


FIG. 9. Portions of induction electric log, microlaterolog, and sonic log of Morrow sands in Cimarron County, Oklahoma.

shown in Fig. 5. The matrix velocity was established as 18,500 ft per sec and the apparent fluid velocity calculated by the Wyllie formula was 4600 ft per sec.

The low apparent fluid velocity was attributed to the inclusion of a substantial amount of residual gas in the invaded sand. Without a proper appreciation of the residual gas, highly optimistic porosity values would be obtained using the sonic log for evaluation purposes.

A further evaluation of the Morrow sand was made using the special graph paper (Fig. 6). Experimental points 1 through 8, from 6360 to 6392 ft and 6418 to 6439 ft, fall substantially below the 11 Ro line and therefore the sand was interpreted to be gas productive. It should be noted that the corrected 16 in. normal points also fall below the FRmf line and further indicate the presence of hydrocarbons.

In order to recognize more easily the presence of gas using this technique, the porosity to transit time relationship for a fluid-bearing formation is used as the abscissa for the graph paper. The casing was perforated from 6360 to 6372 ft and 6420 to 6432 ft, fractured with 6000 gal of lease crude and 3000 lb of sand, then completed on a 24-hr test for 10,440 Mcf per day or a calculated open flow potential of 56,800 Mcf per day.

Fig. 7 includes a portion of the well logs of the Upper Morrow sand in Section 27-1N-20ECM, Beaver County, Oklahoma. Mud resistivity was 1.5 ohm meters at 130 F bottom-hole temperature.

A plot of the transit time and formation resistivity for experimental points 1 through 7, from 7359 to 7390 ft was made using the special graph paper (Fig. 8). The experimental points fall between 4 Ro and 11 Ro. The sand was therefore interpreted to be primarily oil productive.

The corrected 16 in. normal points further verify the presence of hydrocarbons. The sand was perforated from 7364 to 7384 ft and fractured with 2500 gal of acid, 10,000 gal of lease crude, and 10,000 lb of sand. The well tested at the rate of 370 bbl per day of oil.

Fig. 9 includes portions of the well logs of the Upper and Lower Morrow sands in Section 10-1N-9ECM, Cimarron County, Oklahoma. The logs run include the induction electric log, sonic log, and the microlaterolog-caliper. The Upper Morrow sand was cored and analyzed. The weighted core porosity was correlated with the sonic log and a plot made of these data as shown by Fig. 10.

Wyllie's time average equation fits the data and the matrix velocity of 18,500 ft per sec and an apparent fluid velocity of 4520 ft per sec was established. The low apparent fluid velocity is as anticipated for a gas-bearing sand. Analyses of the two sands using the special graph paper is shown by Fig. 11. Experimental points 1 and 2 from the upper sand fall in the 4 Ro to 11 Ro range and therefore it was interpreted to be oil productive.

The corrected 16 in. normal and microlaterolog points also indicated the presence of hydrocarbons. Points 3 and 4 for the lower sand indicate a water bearing sand. The 16 in. points fall near the FRz line and the mircolaterolog points fall near the FRmf line as expected for a water-bearing sand. The upper Morrow sand was perforated from 4624 to 4631 ft, and fractured with 6000 gallons of crude oil and 6000 lb of sand. The well was then completed for a calculated open flow potential of 4600 Mcf per day.

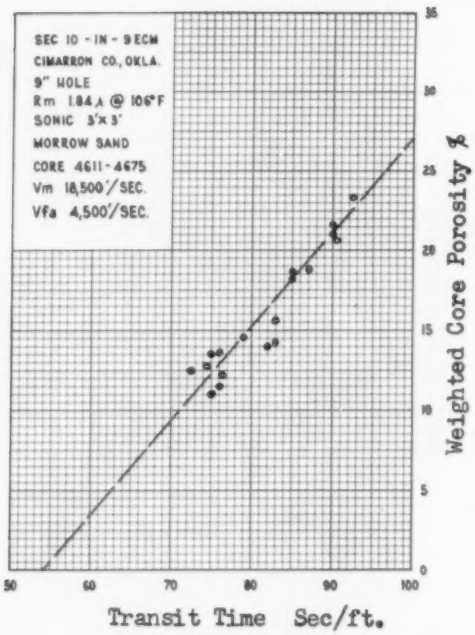


FIG. 10. Upper Morrow sand was cored and analyzed. Weighted core porosity was correlated with sonic log and a plot made of these data. Wyllie's time average equation fits the data and the matrix velocity of 18,500 ft per sec and fluid velocity is as anticipated for a gas-bearing sand.

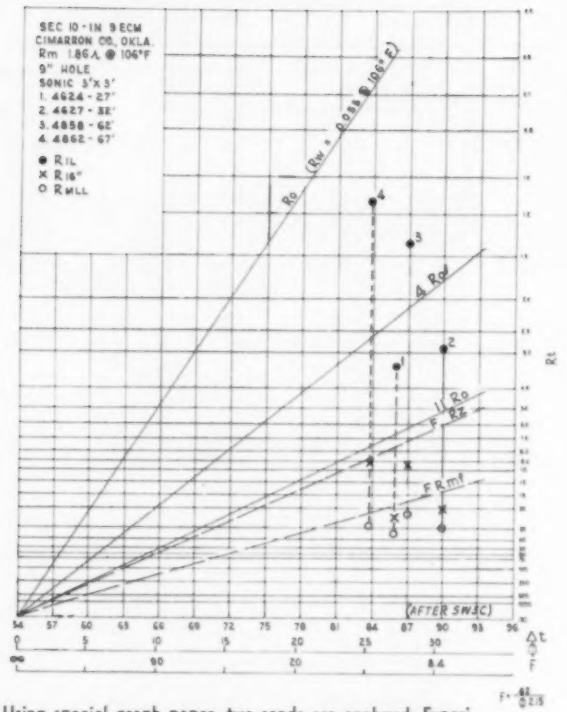


FIG. 11. Using special graph paper, two sands are analyzed. Experimental points 1 and 2 from the upper sand fall in the 4 Ro to 11 Ro range, therefore zone was interpreted to be oil productive.

Since the qualitative interpretation did not agree with the testing, some speculation occurs as to the unqualified success of this evaluation approach. The sonic log is definitely affected by the residual gas as shown by the weighted core porosity-to-transit time plot. Therefore, a lower indicated water saturation should be anticipated for the gas productive sand using this technique.

A possibility for error could occur in the estimation of true formation resistivity using the induction log if an annulus effect were present. This condition seems to be the most logical one, however, it cannot be verified since no other resistivity logs useful for the determination of true formation resistivity were run.

Conclusions

In conclusion, it has been demonstrated that sonic logs run in conjunction with induction electric logs can be used to qualitatively evaluate the Morrow sands in Western Oklahoma.

A knowledge of the matrix velocity for the relatively shale-free Morrow sand has been obtained by comparing core data with the sonic log. The average value for the matrix velocity for several wells in Western Oklahoma is 18,500 ft per sec. The average apparent fluid velocity for oil and water sands is of the order of 5700 ft per sec. For gas sands the problem is more complex because of the residual gas. However, an apparent value of 4600 ft per sec seems to be indicated by the available data.

A plot of the transit time and true formation resistivity utilizing the special graph paper can point out the potential oil or gas producing formations and may delineate between the oil and gas sands under ideal conditions. The transit time should also be compared with the corrected 16 in. normal and Rxo values obtained from microsurveys. This data will permit the recognition of hydrocarbons in the invaded zones.

The induction log generally provides a reasonable estimate of true formation resistivity although it must be recognized that excessive invasion or an annulus effect could seriously reduce the efficiency of the log.

Nomenclature

R_T = True formation resistivity

$R_{16\ in.}$ = Corrected resistivity logged by 16 in. normal

R_{IL} = Apparent resistivity logged by induction log-5FF40

R_{MLL} = Apparent resistivity logged by microlaterolog

Ro = Resistivity of water bearing formation

Rxo = Resistivity of flushed zone

Rm = Resistivity of drilling mud

Rmf = Resistivity of mud filtrate

Rw = Resistivity of formation water

z = Ratio of formation water to total water in invaded zone

Rz = Resistivity of fluid (Rw + Rmf) in invaded zone

ϕ = Formation porosity

F = Formation factor

Δt = Transit time

V = Formation velocity

Vm = Matrix velocity

Vf = Fluid velocity

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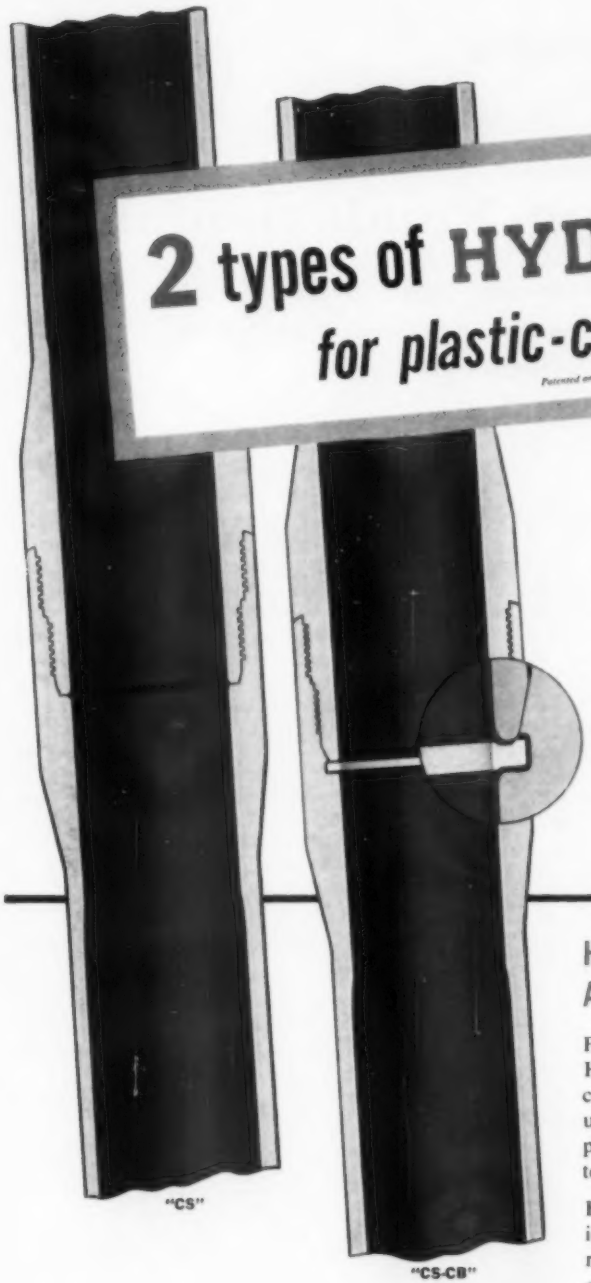

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MODERN WELL COMPLETION SERIES

PART 8A

Formation Testing Fundamentals

Preliminary formation tests provide valuable production information without the expense of completion operations

Cecil R. Richardson
Halliburton Oil Well Cementing Company
Duncan, Oklahoma

FORMATION TESTING, first developed about 35 years ago, is a method of learning something about the producing potential of a formation by removing the hydrostatic pressure of the drilling fluid column from the formation and allowing formation fluids to flow into the empty drill pipe. Data obtained in these tests include quantity and quality of produced fluids during a measured time interval, flowing and closed-in pressures, and rate of pressure build-up with the formation closed in.

Formation testing is the most reliable method known for evaluating a potential reservoir short of completing the well. Economics of the method are obvious since it eliminates the necessity of completing the well to test potentially productive formations.

Development of Procedures

The basic procedure of testing a formation, when the idea was first introduced, required only a cone packer and a simple valve called a stopcock testing tool. The procedure was to core below the drilled hole with a bit of smaller diameter. The cone packer was set on the shoulder provided and the valve was opened to allow the formation to produce into the empty drill pipe. This technique is shown schematically in Fig. 1.

Prior to the introduction of this equipment the producing ability of a formation could be determined only by bailing fluid from the open hole or by setting casing and subsequently bailing or swabbing fluid from the casing to reduce the hydrostatic pressure head on the formation.

The same fundamental principle of formation testing is still employed; however, constant improvements in equipment and techniques have made it possible to use this procedure for gaining much valuable information to aid in evaluating subsurface formations.

The basic equipment required for a formation test is a packer and a tester valve to be run in the hole on drill pipe or tubing (Fig. 2). The packer provides a seal between the wall of the hole and the outside of the drill pipe above the formation and supports the hydrostatic pressure load of the well fluid. The tester valve prevents entry of fluid into the pipe until the packer is seated, after which the valve is opened to provide communication from the isolated formation below the packer into the empty drill pipe.

The lower end of the packer must be supported so that pipe weight can be applied to compress and expand the packer rubber. This also helps prevent the packer from moving down the hole when the hydrostatic weight of the well fluid is applied to the packer. This support is usually furnished by perforated anchor pipe which rests on the bottom of the hole for open-hole testing or by wedge-actuated gripping members which engage the wall of the casing when testing in cased holes.

Present Methods

The present-day formation testing string consists essentially of a complex arrangement of subsurface valves. These valves, capable of being manipu-

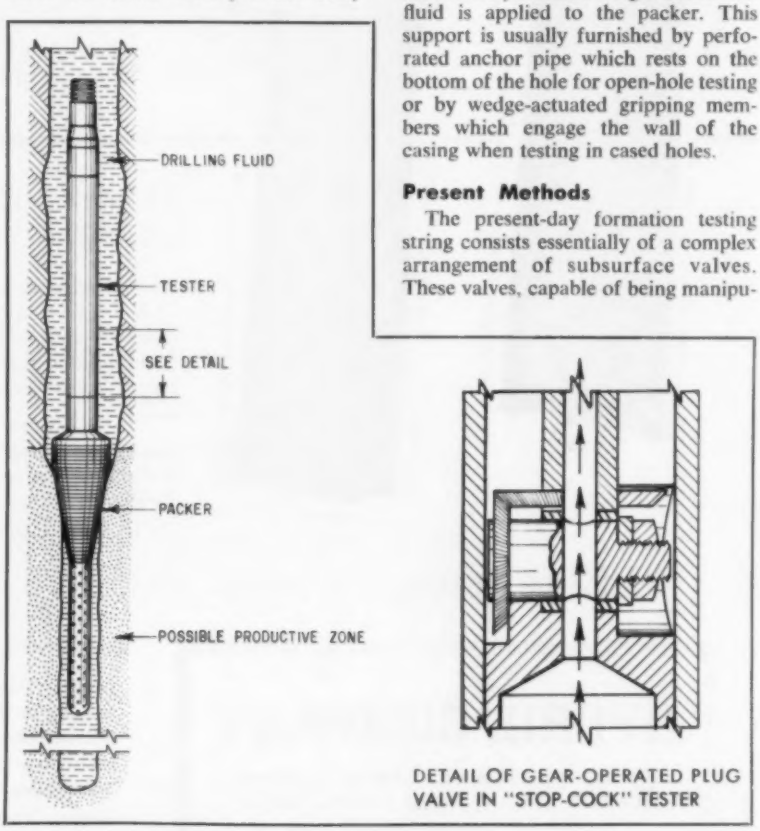

FIG. 1. First formation testing tool consisted of a stopcock tester used with a cone packer.

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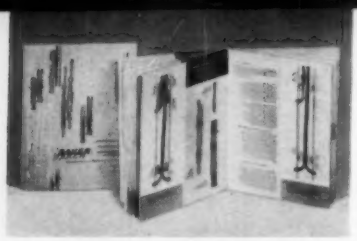

THE FACTS ABOUT MULTIPLE COMPLETION

Yours for the asking is Baker's Multiple Completion Guide, pictured above. It's a 24-page booklet of important engineering facts. In it are 13 of the latest and most practical hookups—dual zone, triple zone, quadruple zone. Write to Baker Oil Tools, Inc,. P.O. Box 2274, Terminal Annex, Los Angeles 54, California.

*9 Modern Production Packers

These are

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Product No. 415-D

The most widely used drillable packer in the world. Contains continuous sealing bore and flapper-type back-pressure valve.

BAKER MODEL "DA" RETAINER PRODUCTION PACKER

Product No. 415-DA

Direct variation of Model "D" with a larger I.D. sealing bore located in the upper end of the packer. Permits larger bore through packer accessories. Used as an upper packer in two-packer flowing or pumping, parallel string hookups.

Single-Zone? Multiple-Zone? Water-Flooding? Deep Wells? Shallow? High Temperatures? Formidable Pressures? ■ The nine packers pictured here handle an impressive array of tough and simple production jobs.

* If you count the pictures, you come to number 9. But that's certainly not the total of packers made by Baker. For instance, Models "J" & "K" Snap-Set Packers are also made in double-grip versions. Model "E" is also offered with integral one-shot unloader, or with unloader and hold-down. Moreover, thanks to Baker's continuing program of packer research and development, new packers that will supplement the packers pictured above are coming.

Drillable

BAKER MODEL "F" RETAINER PRODUCTION PACKER

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Related design to Model "D". Contains larger continuous bore than Model "D" Used where extra large bore is required in some parallel (triple) string, flowing or pumping hookups.

BAKER MODEL "FA" RETAINER PRODUCTION PACKER

Product No. 415-FA

Related to the Model "F" Packer in the same manner that the Model "DA" is to Model "D". Contains extra large upper sealing bore. Provides largest I.D. of any retainer-type packer. Used in multiple string hookups exclusively.

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(left)
Model "J" Single-Grip Snap-Set Dual Packer
Product No. 756-J

(right)
Model "K" Single-Grip Snap-Set Dual Packer
Product No. 756-K

BAKER MODEL "M" SNAP-SET PACKERS

Product No. 635-M

Used as the upper retrievable packer in two-packer, full-opening, selective cross-over, tubing and annulus production hookups. Set with set-down weight. Released and recocked for repeat setting by picking up on tubing.

BAKER MODEL "A" RETRIEVABLE TENSION PACKER

Product No. 739-A

One of the shortest, most modern high-performance tension packers. Ideal for economical, low- or high-pressure water flooding. Rugged enough for many high-pressure fracturing and acidizing operations. Simple J-Slot setting mechanism.

BAKER MODEL "E" RETRIEVABLE CASING PACKER

Product No. 420-E

One of the shortest, most compact, set down retrievable packers available. Ideal for light or medium duty production requirements, or for all-around water flooding use. Simple J-Slot setting mechanism.

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BAKER OIL TOOLS, INC.
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Baker packers don't go into the field alone. One of the great domestic oilfield service organizations stands behind them. Parts are always available, and so is service. So is the latest practical knowledge of how to use packers and how to set them.

BAKER

lated to the various positions of open and closed by surface movement of the pipe, are lowered into the hole on drill pipe along with a compression type wall packer. Four basic valves are required for a conventional test. The function of each of the valves is illustrated schematically in Fig. 3.

Going in the hole (Fig. 3A). The first valve above the packer is a by-pass valve, which is open while going in the hole to make the descent of the packer into the hole easier. Since the packer rubber must expand to seal against the wall of the hole, it is desirable to limit the amount of expansion by maintaining the packer diameter as near to the size of the hole as possible. This results in a limited clearance space between packer and hole, and consequently a restricted fluid passage. If all of the well fluid were forced to pass through this restricted passage as the packer is lowered into the well, the resulting piston effect would cause a pressure build-up below the packer. This could cause difficulty in moving the packer to bottom and could result in damage to a subsurface formation.

The second valve above the packer is the tester valve. This valve is closed while going in the hole to prevent entry of well fluid into the drill pipe. Thus, the drill pipe remains empty and at atmospheric pressure.

Making test (Fig. 3B). When the tools reach bottom, drill pipe weight is applied to compress the packer rubber longitudinally, causing it to expand laterally to contact the wall of the hole. This same downward movement of the drill pipe causes the by-pass valve to close and the tester valve to open. The formation below the packer is now relieved of the hydrostatic pressure of the well fluid, which is entirely supported by the packer. The formation is then exposed through the open tester valve to atmospheric pressure so that it may produce into the empty drill pipe.

The hydrostatic pressure of the mud above the packer has not been changed, thus it still prevents entry of fluids into the well bore above the packer and continues to help prevent sloughing or heaving of the formations.

Taking closed-in-pressure (Fig. 3C). At the completion of the flowing period of the test it is usually desirable to blank off the fluid passage so that the actual rate of closed-in pressure build-up can be measured. This operation is accomplished by closing the third valve in the string, which is a closed-in pressure valve, without disturbing the packer seal, ordinarily by drill pipe rotation. Under these conditions the formation is still relieved of hydrostatic mud pressure and is still trying to produce; however, since the closed valve prevents entry of the fluids into

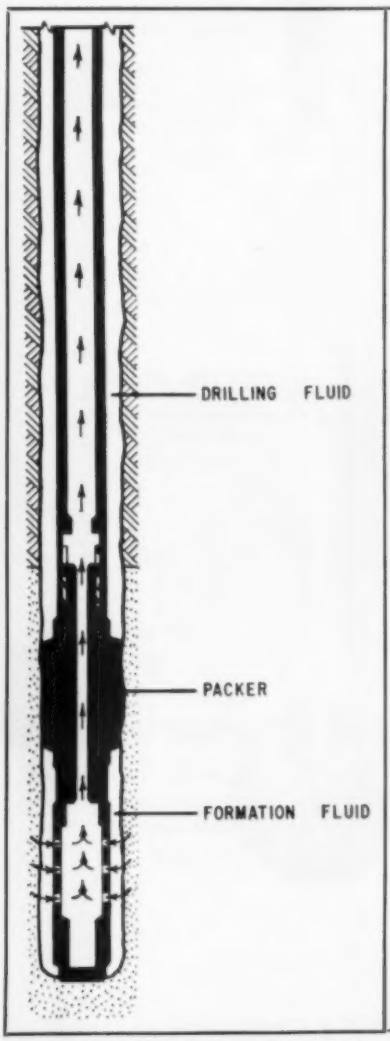

FIG. 2. **Schematic diagram** of a typical open-hole formation test.

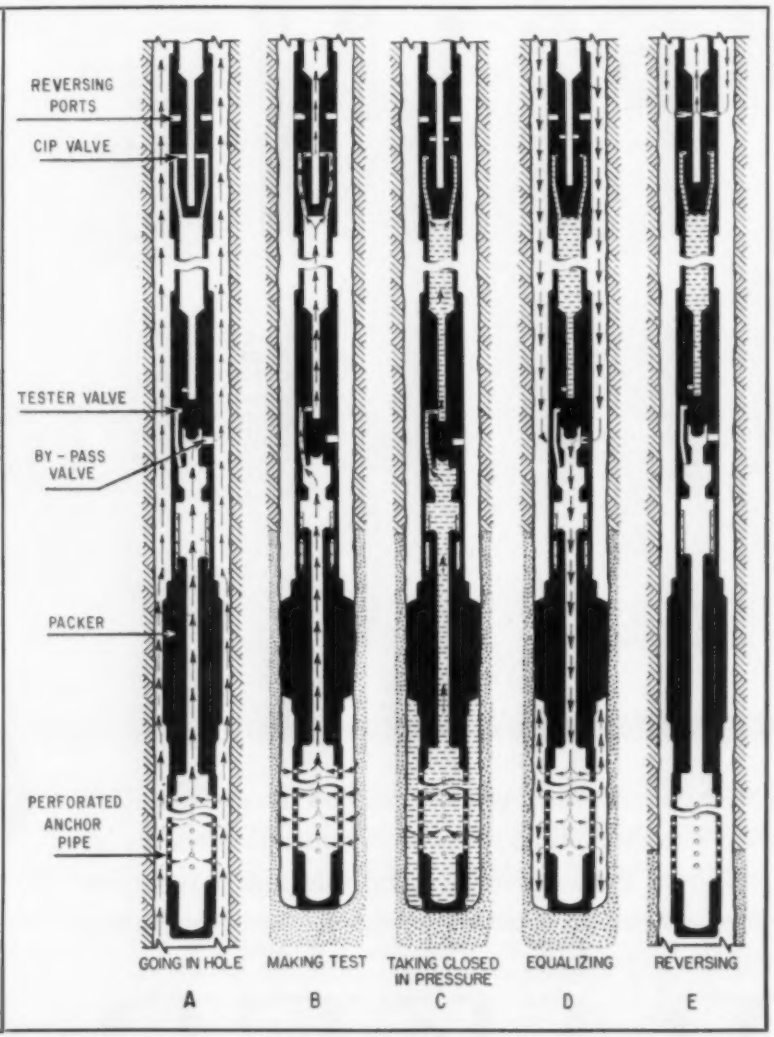

FIG. 3. **Sequence of steps** in typical formation test shows fluid passages through the tools.

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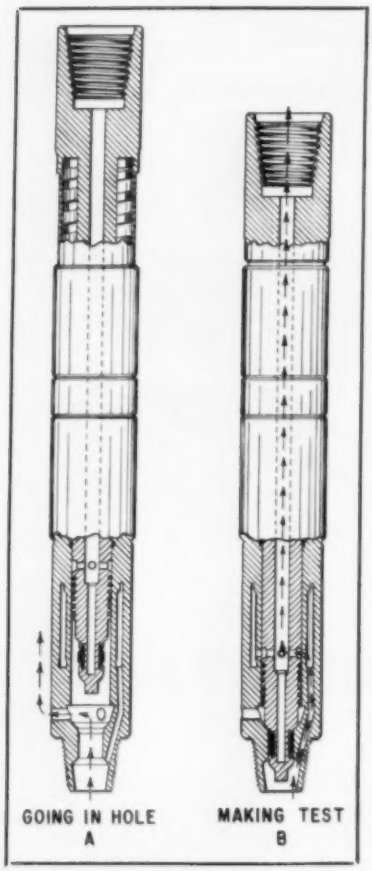

FIG. 4. **Operational diagram** of tester.

FIG 5. **Operational diagram** of closed-in pressure and circulating tool.

the drill pipe, a pressure build-up toward static formation pressure results.

Equalizing (Fig. 3D). The next operation is to unseat the packer to remove the testing tools from the hole. Here the by-pass valve has a second very important function.

Upward movement of the drill pipe causes the tester valve to close and the by-pass valve to open. The open by-pass valve permits hydrostatic mud pressure to be exerted through the center of the packer to the formation below, so that pressure above and below the packer is equalized. This makes it much easier to unseat the packer since it is not necessary to lift the entire weight of the fluid column in the well.

A sample of formation fluid is trapped between the closed tester valve and closed-in pressure valve. This sample remains uncontaminated and can be analyzed when the tools reach the surface.

Reversing (Fig. 3E). The fourth valve in the string, a reverse circulating valve, is provided as a safety measure. The drill pipe may be partially or completely filled with formation fluid at the completion of the test. It is usually desirable to remove this fluid from the pipe before starting out of the hole. This can be done by opening the reverse circulating valve, which provides communication from the annulus to the inside of the drill pipe above the tester valve.

Hydrostatic pressure of the mud, along with pump pressure in the annulus, forces the fluid in the drill pipe to the surface where it can be disposed of under controlled conditions. This helps eliminate fire hazard from spilling oil or gas over the rig floor each time a joint or stand of pipe is unscrewed while coming out of the hole.

brass tacks

FROM HALLIBURTON

"Dry" hole turns producer

Fracpac whips sand-up problem in old well

Hydra-Jet and MCA save Wyoming well

FRACTURING FACTS

The cable tool crew was very disappointed when tests showed this shallow well in Eddy County, New Mexico to be a dry hole. Halliburton was called to do a Sandoil Fracturing Job using 79,550 gallons of lease crude and 2,800 sacks of sand. Injection of approximately 7,600# of sand/per minute was easily accomplished with Halliburton's versatile pumping, proportioning, and bulk sand handling equipment. After recovering fracturing oil, the "dry" hole tested out at 121 bbls./day.

This old well in Jackson County, Texas could not be produced because sand and shale continually flowed into the hole. With Halliburton's Fracpac technique, 28,000# of 20-40 and 2,000# of 10-20 sand was pumped into the formation and well bore to serve as a filtering medium. A liner was then inserted to retain the filtering sand. Since treatment 34 months ago, the well has produced 22 bbls./day. Numerous other wells in this same area have also been converted to profitable producers by this technique.

After completing this new Tensleep well in Hot Springs County, Wyoming for 35 bbls. water with trace of oil, operator was about ready to abandon. He talked to Halliburton and decided to squeeze perforations with 100 sacks of Pozmix Cement, then re-perforate with Halliburton Hydra-Jet. After squeezing four holes were placed in each of three intervals 3261-67. 250 gallons of Halliburton Mud Cleanout Agent (MCA) was spotted opposite the intervals and pumped into the zones to clean the formation. Production 1½ months after treatment was 112 BOPD and 238 BWPD.

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This reverse circulating valve can also be used for circulating and conditioning mud if necessary prior to removing the drill pipe from the hole.

Equipment Operation and Design Principles

Valves described above are embodied in subsurface tools designed to be attached to drill pipe for running in the hole. Operating mechanisms of these various tools, as well as other auxiliary equipment, are controlled and manipulated by one or more of the following methods:

1. Rotary or vertical movement of the drill pipe.
2. Hydraulic pressure — either hydrostatic pressure, pump pressure, or formation pressure.
3. Impact of a falling object dropped into the pipe, such as a bar.

Various mechanisms are used to hold the moving components of the tools in the proper position until it is desired to operate them. These mechanisms include J-slots, springs, lugs and splines, shear pins, differential area on which hydrostatic pressure acts, and hydraulic piston arrangements.

Modern development in formation testing equipment has tended toward combining more than one of the basic valving arrangements in a single tool body. Such combination tools are desirable since they tend to shorten the string of testing tools, decrease the number of connections to be made with consequent saving of rig time, and simplify operation of the tools. Two types of tools which incorporate multiple valve arrangements are described below.

Tester. The tool which contains the valve that prevents entry of fluid into the drill pipe while the testing string is run in the hole is called a tester. The tester must be so constructed that the valve is held closed until the tools are in position for the test. Also, means for surface manipulation to open the valve to make the test and to close the valve at the completion of the test must be provided.

A tester operated by simple vertical movement of the drill pipe is shown in Fig. 4. This is a combination tool, incorporating with the tester valve a locked open by-pass valve.

The tester is installed in the testing string above the packer. Fig. 4A shows the tester as it is run in the hole, with the tester valve closed. The by-pass valve is open, providing fluid passage from below the packer back into the annulus.

When the testing string reaches bottom, drill pipe weight is applied to set the packer. As this weight is applied, the tester valve begins to move into the position for opening. The valve is so constructed that a definite time interval elapses before it reaches the opening position.

During this time interval, usually two to five minutes depending upon the amount of drill pipe weight applied and upon the pre-determined setting of the valve, the packer is being expanded against the wall of the hole. This helps the packer rubber to seat firmly before hydrostatic pressure is applied to it. At the end of the time interval the by-pass valve closes and the tester valve opens rapidly, giving a definite indication at the surface. The rapid opening of the valve helps prevent fluid cutting of the valve ports as the pressure below the packer is released into the empty drill pipe.

The tester valve and by-pass valve have now moved to the position shown in Fig. 4B, providing a fluid passage from the area below the packer, through the tester valve, and into the drill pipe above.

When drill pipe weight is removed from the tool, the tester valve closes. The by-pass valve opens to equalize pressure around the packer. There is no time delay in the upward movement of the valves. Removal of weight from the tool allows the valves to be instantaneously repositioned, so that the full time interval is required for re-opening the tester valve.

Closed-in-pressure and reverse circulating tool. Fig. 5 shows an operational drawing of another combination tool which incorporates the two valves required for taking closed-in pressure and for reversing circulating.

This tool may be run anywhere above the tester. Usually two or three

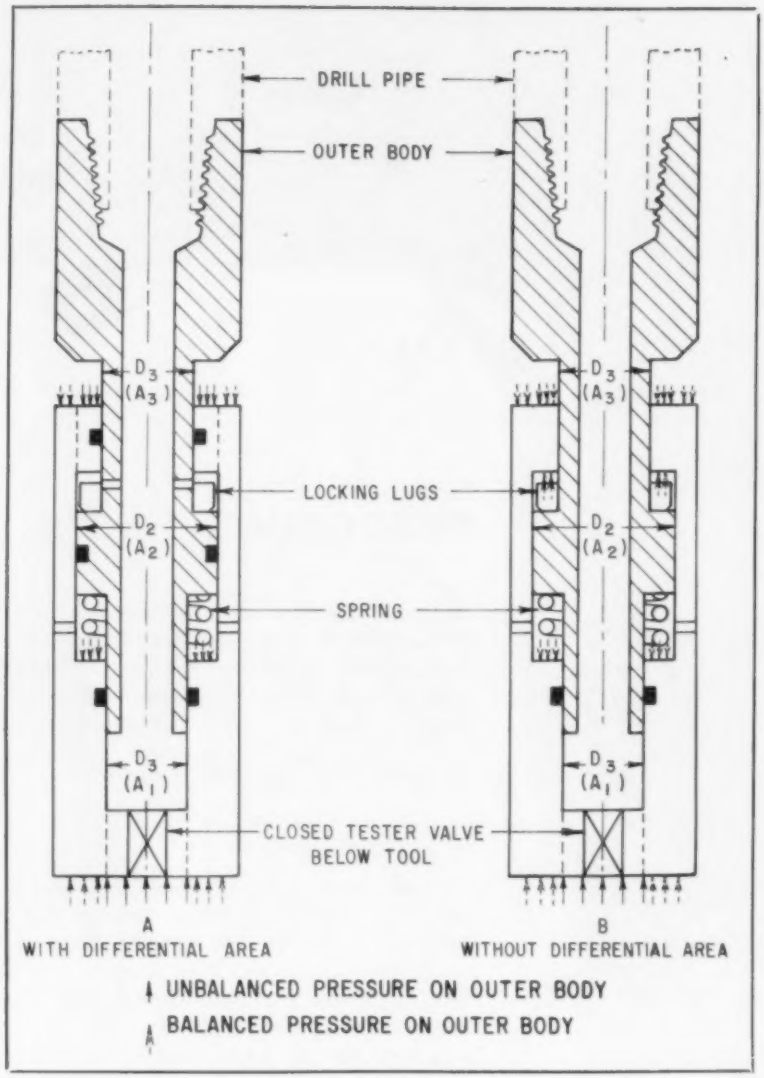
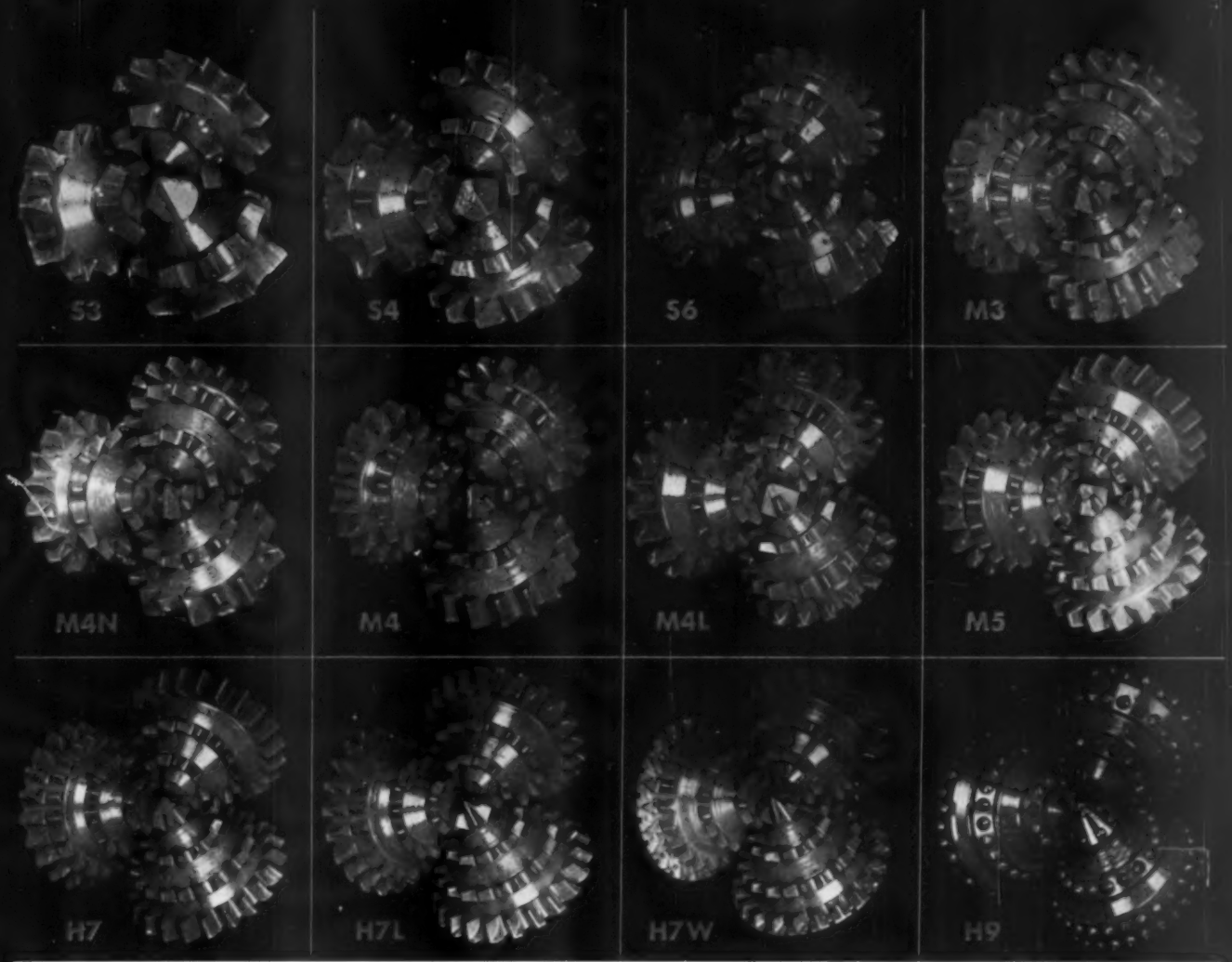


FIG. 6. Closed-in pressure and reverse circulating tool.



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joints of pipe are placed between the two tools, allowing sufficient capacity for containing an uncontaminated sample of the formation fluid, which is trapped and retrieved between the two tools at the completion of the test.

The tool contains a screw-thread actuated sliding valve mechanism consisting of "O" ring seals which move over ports to control the fluid passage through the tool. A set of locking lugs is provided to help prevent premature operation of the valve. These lugs are held engaged by a heavy spring plus the hydrostatic mud pressure acting over a differential area provided for this purpose. These forces are overcome by drill pipe weight applied to set the packer and open the tester valve. Excess weight is transmitted through the tool by a large capacity thrust roller bearing.

Fig. 5A shows the tool as it is run in the hole with the locking lugs engaged and the fluid passage open. No fluid passes through the tool at this stage however, since it is run above the closed tester valve.

Fig. 5B shows the position of the tool mechanism during the flowing test. With packer set and tester valve open the formation fluid is free to flow through the tool as shown by the arrows. The locking lugs have been disengaged by drill pipe weight.

With the locking lugs disengaged, right hand rotation of the drill pipe actuates a screw-thread mechanism in the tool which causes the sliding valve to move up to the position shown in Fig. 5C. In this position the flow passage through the tool is shut off so that the formation closed-in pressure is being measured.

Further right hand rotation of the drill pipe moves the sliding valve to the position shown in Fig. 5D, opening the valve ports to the annulus to allow reverse circulation. This operation may be performed while measuring closed-in pressure if desired since the formation fluid passage through the tool is still closed in this position.

Fig. 5E shows the position of the tool while the testing string is being removed from the hole. The locking

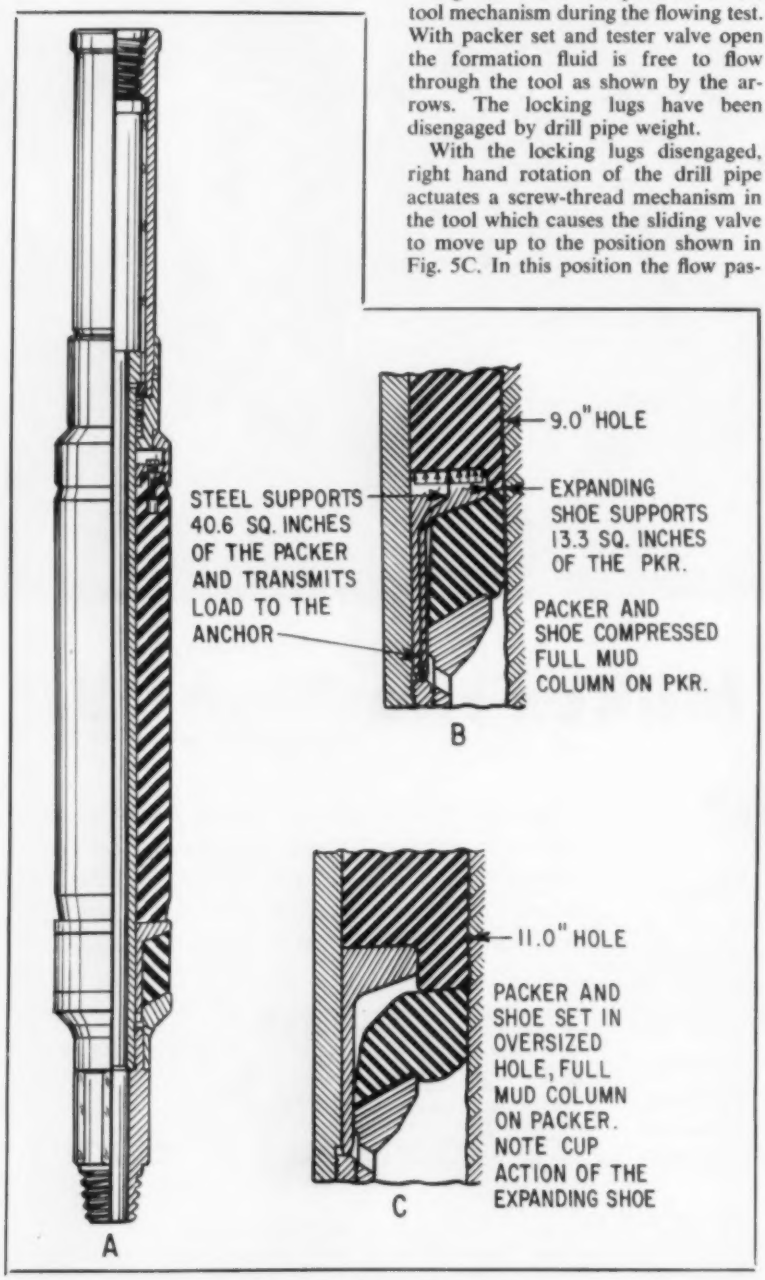
9.0" HOLE
STEEL SUPPORTS 40.6 SQ. INCHES OF THE PACKER AND TRANSMITS LOAD TO THE ANCHOR
EXPANDING SHOE SUPPORTS 13.3 SQ. INCHES OF THE PKR.
PACKER AND SHOE COMPRESSED FULL MUD COLUMN ON PKR.
B
11.0" HOLE
PACKER AND SHOE SET IN OVERSIZED HOLE, FULL MUD COLUMN ON PACKER. NOTE CUP ACTION OF THE EXPANDING SHOE
C
A

FIG. 7. Typical open-hole packer.

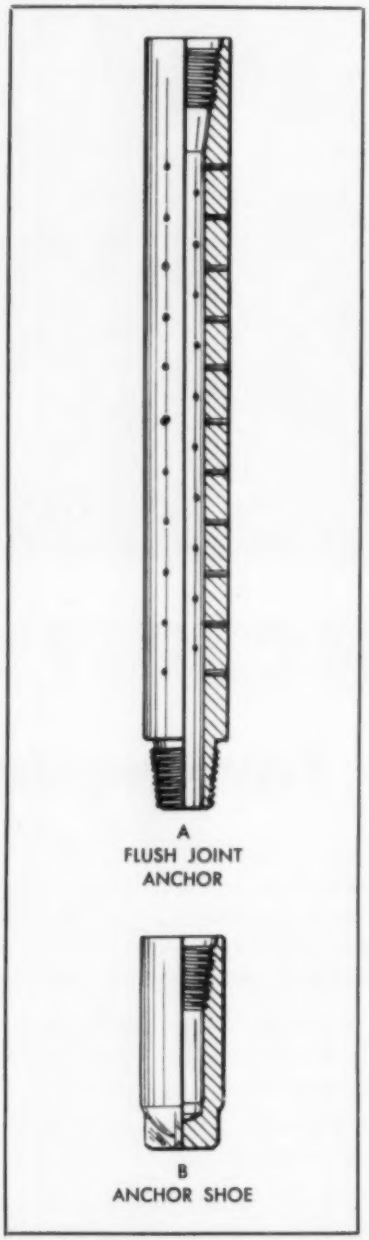

FIG. 8. Flush joint anchor and anchor shoe.

Move the man off the monkey-board

GUIBERSON

*Type **H** Hydraulic*

WIRE LINE OIL SAVER

Hydraulically operated, Guiberson's Type H Wire Line Oil Saver is controlled remotely by applying or releasing hydraulic pressure through a 50′ hose from pump to saver. The Type H effectively and uniformly cleans the wire line. This keeps the working area and equipment free of well fluids, reducing the hazards of fire and accident. Comply with Guiberson's slogan, "Better Be Safe Than Sorry," by using the Type H. There is no need for a man on the monkey-board during swabbing and redressing operations, which should please your insurance company.

Advantages of Type H Saver:

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Non-sparking, durable split bushings . . top and bottom interchangeable.

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Bushings and rubbers for ⅜" to ⅝" or ¾" to 1" line.

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OTIS PRODUCTION NEWS

Volume I, Number 1 **Otis Engineering Corporation • Dallas** *Production Equipment and Services*

Special Report from West Texas

Otis Production Packers Hold Where Others Fail

High Pressure, Strain, Tubing Vibration in Gas-Injection Wells Cause Bodies of Competitive Packers to Part

MIDLAND — Type WA Otis Production Packers have proved to be the solution to a serious problem encountered by a West Texas operator on a secondary recovery project. The problem was to find a packer that would stand the stress and vibration of the tubing in a number of high-pressure gas-injection wells.

The wells involved were being used to inject gas into the Devonian at approximately 12,500 feet. Injection rate was 2½ M.C.F.D. at 7,500 P.S.I. Due to vibration created by this high rate of injection, the tubing was set in tension with a minimum of 25,000 pounds' strain. These conditions apparently proved too strenuous for the packers used in the initial completion for they disintegrated shortly after the wells were put into operation.

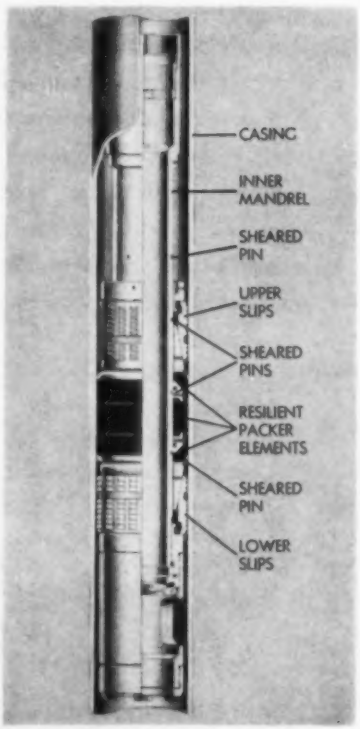
In analyzing this producer's problem, Otis packer specialists from the Odessa office felt confident the Type WA Otis Production Packer would stay in the hole in spite of the adverse working conditions because of the packer's "floating mandrel" design.

See diagram this page

This feature, unique among permanent-type retainer packers, is designed to prevent problems such as this which result when a packer's inner mandrel is permanently attached to the slips or packer body.

Unlike the packers originally used in these wells, the inner mandrel of the Type WA Otis Packer is not pinned to either the upper or lower slips, or the rubber element assembly, once the packer has been set. The mandrel is free to travel up or down within the outer packer body approximately 8 inches before being confined by a shoulder at either end, and is sealed off and held in position by O-rings and pressure from the compressed rubber packer elements. In this way, vibration or movement of the tubing string when transmitted to the packer mandrel is partially absorbed by the rubber packer elements first, and not directly transmitted to the slips or the outer packer body.

As a result, Type WA Otis Production Packers have replaced the packers originally used in these injection wells and the operator reports all have proved satisfactory. Several additional wells are to be drilled for this project and Type WA Packers have been specified for each.



When setting the Type WA Otis Production Packer, all pins holding the slips and resilient packer elements in the running position are sheared and the mandrel is free to float.

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Drilling and Producing Division Heralds Otis' Entry Into Packer Field As 'Good News'

DALLAS — The news that Otis has acquired a new line of field-proven production packers and bridge plugs, and is now offering a "packaged" well completion service, has been well received by the drilling and producing division of the petroleum industry.

For the last 25 years, producing companies and packer manufacturers both have looked to Otis for guidance when engineering difficult well completions. Now, with its own line of packers, Otis will provide the industry a "packaged" well completion service to include both engineering and all sub-surface equipment.

The present line of Otis packers includes a series of Type WA Wire Line Set Drillable Retainer Packers which can be set on any wire line pressure setting tool; three tubing or drill pipe set packers which carry the designations Type TA, TB, and TE; a Type RA Retrievable Packer designed to be set in tension or com-

(See "Good News," Page 2, Col. 2)

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Better Production Tools Through Research

Otis-Engineered Dual-Completion Saves Tubing Job 30 Days Following Initial Completion

THOMPSON CREEK FIELD, MISS. — A well, dually-completed in this western Mississippi field in November, 1959, produced approximately 200 B.O.P.D. from each zone immediately following completion, however both zones had to be put on pump in less than thirty days due to a decrease in bottom-hole pressure. The well completion, engineered by Otis specialists in that area, was designed to permit the operator to flow this well as long as economically feasible, then put both zones on pump without pulling tubing.

The well was completed with two packers, a dual and a single, a Type S Otis Landing Nipple and a Sliding Side-Door® between the two packers for plugging and circulating purposes, and two Type S Otis Landing Nipples above the top packer in each string.

See schematic diagram — right

The conversion of this well to artificial lift was accomplished by landing Type S Otis Pump Locators and Hold-Downs in the top S nipple of each string and installing the pumps. As the zones deplete, the pump locators and hold-downs may be reset in the lower nipple of each string simply by pulling the pumps, retrieving the locators and hold-downs, changing the selective keys on the locators, and re-running the tools to the lower nipple. By using Type S Otis Landing Nipples instead of regular A.P.I. pump seating nipples, the tubing remains full-opening to permit running through-tubing perforating guns, bottom-hole pressure bombs, and other wire line service tools. Also, plug chokes and other Otis sub-surface flow control equipment may be set in any of the S nipples should it become necessary.

Good News

(Continued from Page 1)

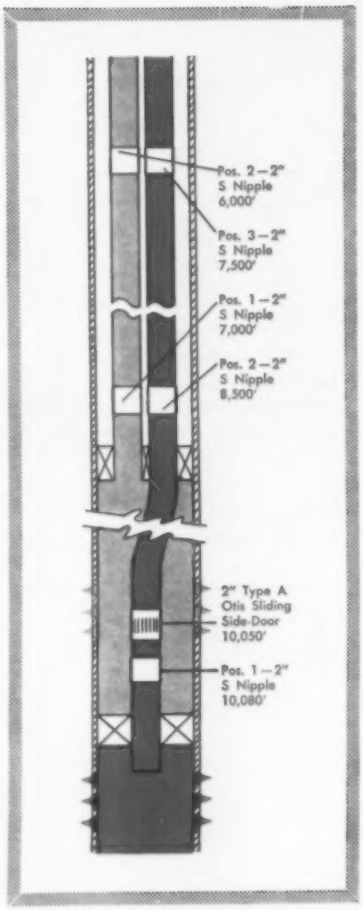
pression without modification; the Type HS Retrievable Isolation Packer which is set hydraulically, and two retrievable collet-type packers — one for slim-hole work and the other a regular casing collet-type packer.

A stepped-up research and development program is expected to produce several new types of packers in the immediate future to further round out the line of packers Otis already offers.

As part of the company's expansion program into the packer and bridge plug field, highly skilled packer specialists have been added to the staff of each Otis division. These men, working with other Otis well completion experts, form a team that operators can look to for a "packaged" well completion . . . as a single supply source for *all* necessary sub-surface completion equipment — from the wellhead to the plug on bottom.

Tool and Service Information

For additional information on any of the equipment reported in this issue of the Otis Production News, contact your nearest Otis office or write Otis Engineering Corporation, Dept. 1-P, Box 35206, Dallas 35, Texas. You'll find your Otis specialist ready to help you — anxious to serve you.

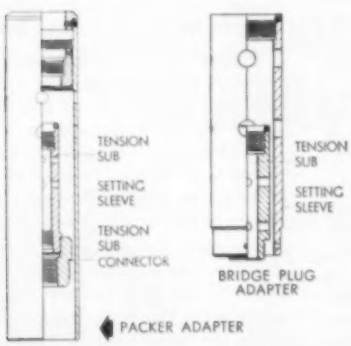

Pos. 2 – 2" S Nipple 6,000'
Pos. 3 – 2" S Nipple 7,500'
Pos. 1 – 2" S Nipple 7,000'
Pos. 2 – 2" S Nipple 8,500'
2" Type A Otis Sliding Side-Door 10,050'
Pos. 1 – 2" S Nipple 10,080'

OTIS

Engineering Corporation

General Offices:

6612 Denton Drive • Dallas, Texas



New Otis Packer and Bridge Plug Pressure Setting Tool Adapter Kits

Special pressure setting tool adapter kits have been developed to permit Type WA Otis Production Packers and Otis Wire Line Bridge Plugs to be set on the No. 20 pressure setting tool. Both of the adapter kits are extremely simple in design and can be easily made up with the setting tool.

The packer adapter kit consists of a tension sub, setting sleeve, and tension sub connector which is made up on top of the WA packer on the rig floor. The adapter for the bridge plug consists of only two sub-assemblies, a tension sub and a setting sleeve.

Both kits have been extensively tested in the laboratory and in the field, and neither has failed to operate as designed.

lugs are re-engaged to permit rotation of other tools lower in the string. The reversing ports remain open to drain the drill pipe, and the formation fluid passage ports remain closed to retain a sample of fluid between this tool and the closed tester valve below.

A spring loaded relief valve in the lower end of the tool permits the pressure of the trapped sample to be dissipated to the annulus as the tool is raised and the hydrostatic pressure in the annulus becomes less than the pressure of the trapped sample. This allows the trapped sample to be brought to the surface at atmospheric pressure.

Differential area. As previously mentioned, a differential area on which hydrostatic mud pressure acts is often used to facilitate the operation of a tool. The above described tool provides a very good illustration of the use of a differential area.

In this case, it is necessary that the locking lugs remain engaged until drill pipe weight is applied to set the packer. A heavy spring is used to hold the lugs engaged while the tool is on the surface. As the tool is lowered in a well, however, it is desirable to increase the holding force on the lugs to help prevent them from being disengaged accidentally. If a sufficiently strong spring were used to provide the necessary force, it would be difficult to compress the spring and disengage the lugs when the tool was operated at shallow depths where the available drill pipe weight is small. However, a differential area, as described below, on which the hydrostatic pressure of the well fluid acts, provides an additional force for holding the lugs engaged. Since the hydrostatic pressure is proportional to depth, the locking force becomes greater as the tool is run deeper. However, since the available drill pipe weight is also proportional to depth, the weight required to overcome the locking force and place the tool in the operating position is always available.

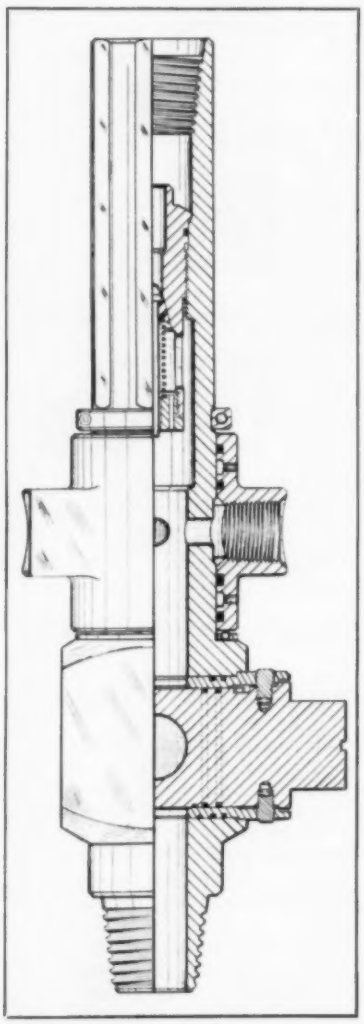


FIG. 9. Control head used during formation test.

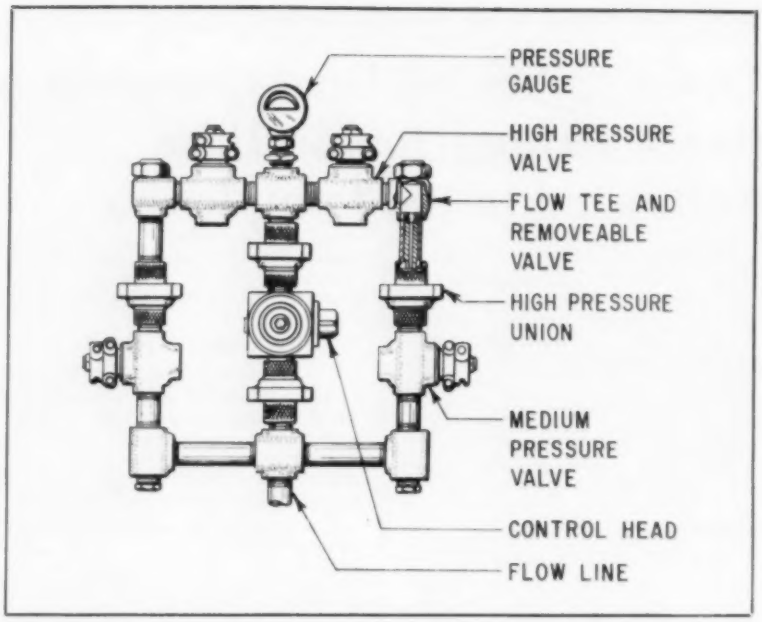


FIG. 10. Manifold of pressure gage, valves, choke tee, and control head.

Fig. 6A is a schematic illustration of this tool. The diameters of the sealing surfaces which prevent entry of well fluid into the drill pipe on which the tool is run are identified as D_1, D_2, and D_3, the areas of which are A_1, A_2, and A_3, respectively. An analysis of the forces created by hydrostatic pressure on the outside of this tool, with the inside of the tool open to atmospheric pressure, shows that hydrostatic pressure acting on the area A_1 tends to raise the outer body of the tool, which contains the upper set of locking lugs. The same pressure acting on the area $A_2 - A_3$, however, tends to hold this outer body down. Therefore, the tool is so designed that the area $A_2 - A_3$ is greater than the area A_1, so that the hydrostatic pressure creates a net force downward on the outer body, holding the lugs in the engaged position.

If this differential area, $A_2 - A_3 - A_1$, is equal to 1.0 sq in., then the force in pounds holding the lugs engaged is equal to the value of the hydrostatic pressure in lb per sq in.

Fig. 6B is a schematic illustration of this tool without a differential area. If the tool were designed in this manner, the only unbalanced force created by the hydrostatic pressure would be due to its action on area A_1 tending to raise the outer body of the tool. In this case the force created by the hydrostatic pressure would tend to disengage the lugs, and if this force became greater than the spring force, the lugs would become disengaged, allowing the valve to be actuated prematurely.

Packer. The open hole wall packer provides a seal between the wall of the hole and the outside of the drill pipe above the formation to be tested. It thus supports the hydrostatic weight of the well fluid so that the formation to be tested can be exposed to atmospheric or reduced pressure.

An adequate supporting member for the lower end of the packer rubber is essential since the rubber tends to extrude over the lower shoe as it supports the weight of the mud column. Without proper support, the packer rubber may extrude to such an extent

New 2 1/16" OD SPANG tubing installed in multiple completion East Texas well.

Now! Spang has 2 1/16" OD tubing for multiple completion wells

Spang has expanded its line of oil well tubing to include 2 1/16" OD tubing. The new, small size is ideal for dual and multiple completion wells. Spang's tubular capacities are constantly being revised in this manner to keep ahead of your requirements for tubing, casing and drill pipe. You'll find it pays to standardize on these Spang products.

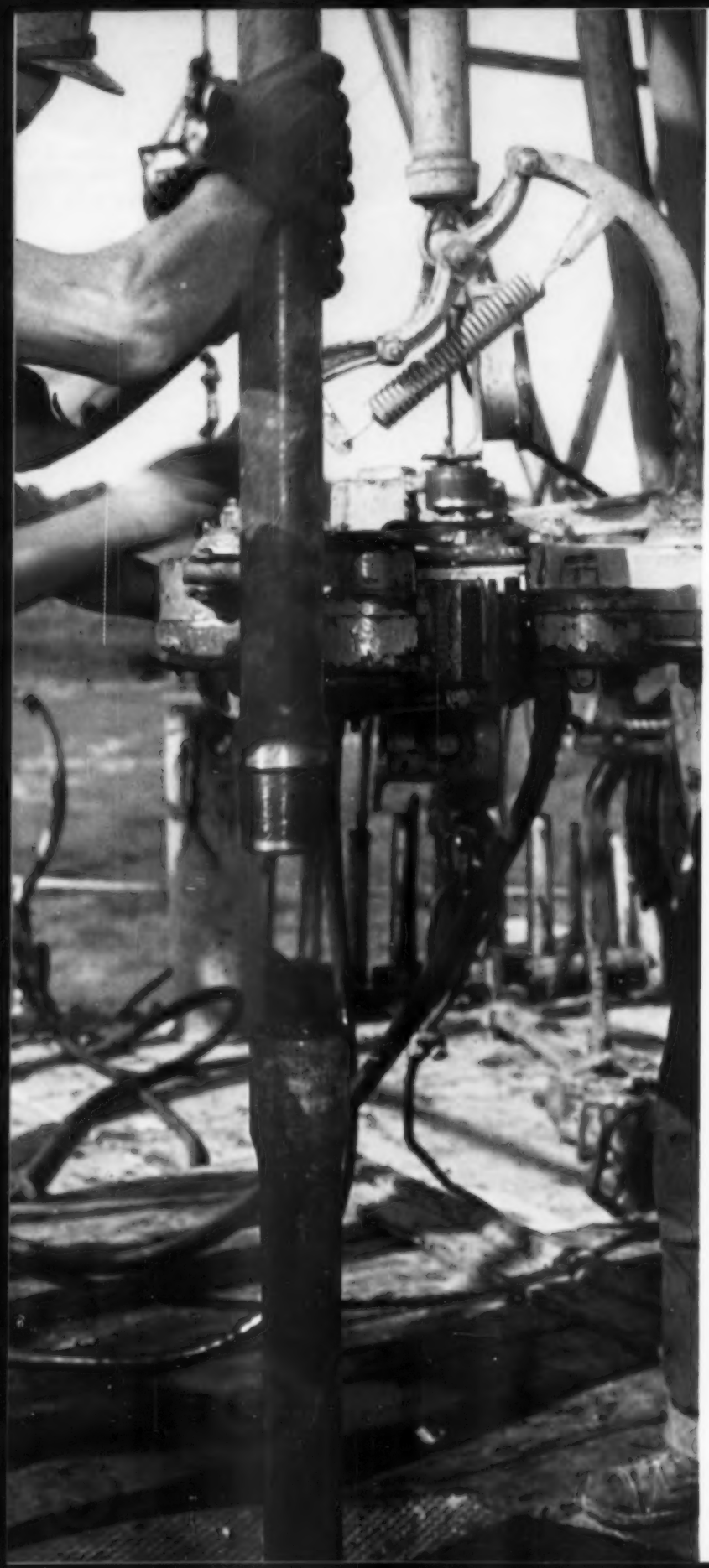
More about Spang tubing on next pages:

New tubing size meets needs of Multiple Completion Wells

Reports from field users verify successful performance of Spang's new, small size tubing in multiple completion wells. The 2 1/16" OD tubing is now available with integral joint (upset) and threaded and coupled joint (non-upset). Respective nominal weights are 3.25 and 3.20 pounds per foot. Both types are supplied in grades J-55 and N-80. Your nearby National Supply representative has complete details. Call him soon.

This integral joint Spang tubing is readily available in grades J-55 and N-80. Tubing is always delivered in factory-perfect condition.

◀ Spang's new leak-resistant 2 1/16" OD tubing was specified for this East Texas multiple completion well.



Streamlined SPANG Extreme Line tubing guarantees positive resistance to leakage

Integral design of Spang Extreme Line tubing results in a sealed joint that is always shoulder tight. Unique metal-to-metal seal resists leakage in the deepest, high pressure wells.

Extreme Line joints are streamlined internally and externally, minimizing possibility of hanging up or stripping under pressure. Integral joint eliminates 50% of the connecting threads in conventional designs.

Wide, heavy, modified Acme threads speed joint make-up with minimum chance of cross-threading.

Spang Extreme Line tubing is available in grades J-55, N-80 and P-105 to meet your toughest well conditions. It rounds out Spang's complete line of tubing for specific applications. Your National Supply representative always can recommend the exact Spang tubing that suits your requirements. Or write for new bulletin covering complete details.

Fast make-up is a sure thing with Spang Extreme Line tubing. Couplings are eliminated. Rugged joint permits repeated make-up and breaking out without galling.

Steel

Steel's Symbol of strength, long life, and economy

Spang CW steel pipe has wide application in gas, oil and water gathering lines.
User reports are unanimously enthusiastic about Spang pipe quality.

Superiority of SPANG CW steel pipe is due to many things . . .

UNIFORMITY Every length is manufactured under identical, closest possible quality controls on Spang's efficient production equipment.

TESTS AND INSPECTIONS All Spang pipe is thoroughly inspected and hydrostatically tested for strength. Each length is easy to cut, bend, thread and weld.

AVAILABILITY National Supply has the manufacturing and distribution facilities to assure availability of all pipe sizes—plain end or threaded and coupled—*when* you need them.

These are only a few of the reasons for the superiority of Spang CW pipe. And you get this special pipe quality without premium price. Call today for prompt delivery.

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Litho in U. S. A.

that it becomes difficult to unseat the packer.

Fig. 7A shows a packer assembly which utilizes an expanding shoe type support for the lower end of the packer rubber. This type of packer has been developed to minimize difficulty in unseating the packer and to minimize misruns, especially in oversize holes.

The expanding shoe is a hard rubber, sleeve type device used below the softer rubber packer to help prevent the packer from extruding, under high temperatures and pressures, over its lower shoe. The unique supporting ability of the expanding shoe also permits the use of a smaller packer in a given size hole. The smaller packer provides increased clearance and thereby decreases packer drag and the possibility of hole damage while running the testing string into and out of the hole.

Fig. 7B shows the action of the expanding shoe when the packer is set in a normal size hole. As drill pipe weight is applied to the packer, the steel support at the lower end of the packer rubber moves down until it comes to rest against another steel part which transmits the major portion of the packer load directly to the supporting anchor. As the steel packer support moves down, it forces the expanding shoe out against the wall of the hole by the wedge action of the angle at the top of the shoe along with a limited compression of the shoe itself.

Unlike the packer rubber, the expanding shoe does not support the full hydrostatic load. It supports only that small part of the packer that tends to extrude over the packer support and is therefore lightly loaded in comparison with its strength. This allows it, as well as the packer whose extrusion has been limited, to return to shape immediately after the load is removed.

Fig. 7C shows the cup action of the expanding shoe when used in an oversize hole. In such a case the packer may be damaged if subjected to high pressure or temperature. However, the possibility of making a successful test is greatly increased because of the added support afforded for the packer.

Anchor. Flush joint anchor pipe, as shown in Fig. 8A, is used below the packer in open hole testing. The primary function of the anchor pipe is to support the mechanical and hydrostatic load applied to the packer. An anchor shoe, Fig. 8B, is made up on the lower end of the anchor pipe and rests against the bottom of the hole.

Anchor pipe is available in various lengths from one to six feet so that the packer can be set any desired distance from the bottom of the hole. It is essential that the sections of anchor pipe be equipped with flush joints to provide a uniform outside diameter. This tends to minimize the possibility

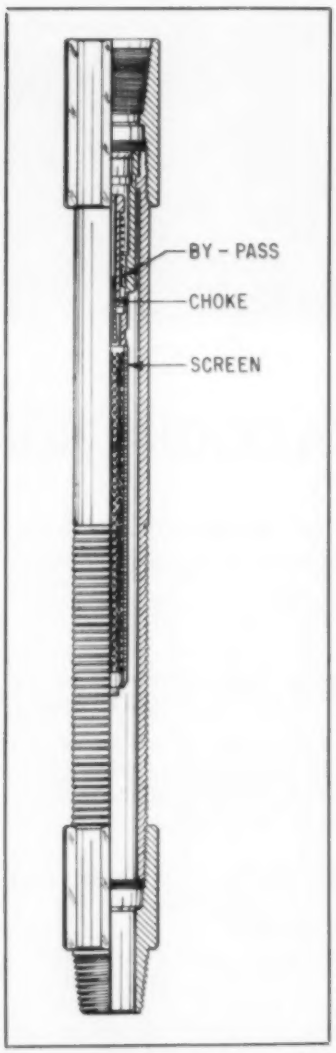


FIG. 11. Subsurface choke assembly.

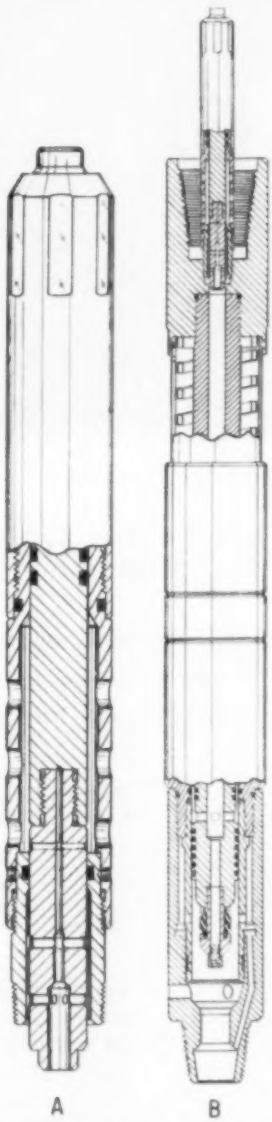


FIG. 12. Hydraulically adjusted bottom-hole choke and method of installation in tester.

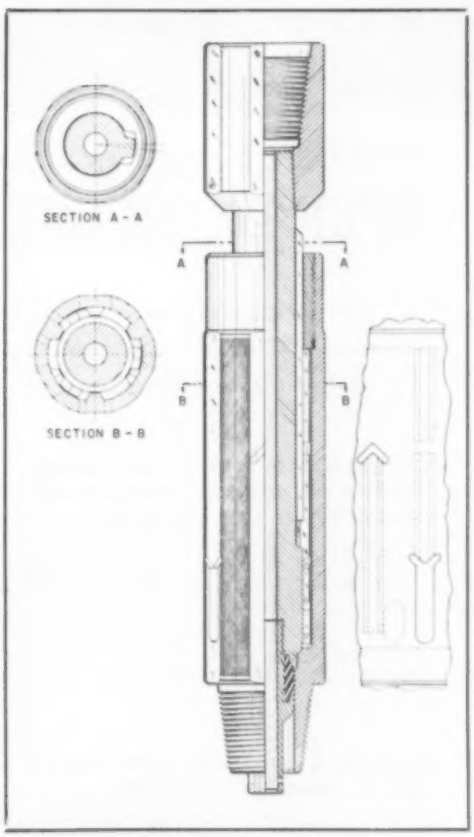


FIG. 13. Safety joint used in test string.

NORTH, SOUTH, EAST AND WEST—

OPERATORS GET FAST PAYOUTS, GOOD PROFITS

You increase net profits when you perform successful workovers on your wells. Dowell services, products and engineering aids are designed to help you get those added profits. Here are results from a few of many recent jobs.

OPERATOR NETS $4715 IN 90 DAYS FROM ABRASIJET AND ACIDIZING BY DOWELL

ALBERTA, CANADA. Three old wells in the Redwater pool produced an *extra* 4520 barrels of oil in 90 days as a result of Abrasijet*—Dowell's abrasive jetting service—and Dowell acidizing treatments. After deducting total workover and treatment costs from added revenue of $10,115, a net profit of $4715 was realized.

DOWELL SAVES GAS WELL— GETS 10-DAY PAYOUT

SOUTH TEXAS. A Dowell frac job made a 2,750 mcfd producer out of an old Frio well that was practically dead and non-commercial. Payout on treatment was estimated at 10 days.

DOWELL FRAC JOB BRINGS NEW LIFE TO 40-YEAR-OLD GAS WELL

WEST VIRGINIA. 850 mcfd open flow and 200 mcfd delivered into line resulted when Dowell fractured a practically dead 40-year-old gas well. Treatment cost was paid out in less than 30 days.

TREATMENTS WITH VERSENE 100 GIVE 35-DAY PAYOUTS IN PERMIAN BASIN

WEST TEXAS. Average payout of ten treatments by Dowell using Versene® 100 was 35 days. Versene 100 is a chemical used to remove calcium sulfate, calcium carbonate and other scales from wells. Average production increase was 9.7 bopd and treatment costs were between $550 and $875. Net value of oil was assumed to be $2.00 per barrel.

WITH DOWELL WORKOVER TREATMENTS

DOWELL USES "ACID GUIDE"* TO GET FAST PAYOUT ON THREE PROBLEM WELLS

NORTH DAKOTA. Payouts of 55, 23 and 65 days were realized from treatments with Retarded Acid of three old wells in the Madison lime of McKenzie County. Previous treatments using regular acid in the same field had failed to pay out.

NEW ACID TREATMENT SAVES OPERATOR ABOUT $400 PER MONTH ON WATER DISPOSAL WELL

SOUTHEASTERN NEW MEXICO. A single $735 treatment replaced three $650 monthly treatments on a Lea County disposal well. By substituting Stabilized Acid and a surfactant wash for regular acid, life of the job was tripled at an extra cost of only $85. Savings averaged about $400 per month.

FRAC JOB PROVIDES EXTRA GAS AT THREE CENTS PER THOUSAND

NORTH LOUISIANA. 105 mmcf of *extra* gas was produced in four years from a well in the Monroe Gas Field. Reason for this extra production was a Dowell frac job performed in March, 1956. Based on treatment price, the extra gas cost the operator three cents per thousand. 39 similar wells fractured early this year promise to be at least as profitable as the 1956 job.

Talk over your workover problems with your Dowell representative. He will show you how Dowell can use new ideas and techniques to help you cut costs and increase revenue. Dowell services and products are offered from more than 150 offices and stations in the United States, Canada, Venezuela, Argentina and Germany. Dowell, Tulsa 1, Oklahoma.

* Dowell Trademark

Services for the oil industry

DOWELL

DIVISION OF THE DOW CHEMICAL COMPANY

of the anchor becoming stuck if shale or sand should settle around it during the test.

Fluid from the formation enters the anchor pipe during the test through perforations. These perforations are usually only ⅛ or 3/16 in. in diameter so that they act as a screen to help prevent entry of shale or other foreign particles large enough to plug the testing equipment. A multitude of holes is provided, sometimes as many as 200 per ft of anchor, to allow sufficient formation fluid passage area.

A portion of the anchor pipe usually serves also as a running case for the pressure recording device.

Auxiliary Equipment

In addition to the basic tools required for a formation test, several items of auxiliary equipment are nearly always used. These increase the efficiency of the testing operation and the amount of information that can be obtained.

Surface control equipment. The surface control equipment is basically a control head installed at the top of the drill pipe. The control head contains a master valve which is used to stop the flow of oil or gas from the drill pipe when desired. A back pressure valve may also be incorporated in the control head to permit fluid to be pumped into the drill pipe if necessary to control abnormally high subsurface pressures.

A swivel is necessary in some instances to permit rotation of the drill pipe for operating the subsurface tools without closing in the well at the surface. One type of control head that incorporates all the above features is shown in Fig. 9.

A flow hose is used to carry the gas or oil away from the drill pipe to the pits or to a test tank during the test. The flow hose is usually connected to the control head by means of a manifold containing valves and chokes so arranged that the chokes can be changed without shutting off the flow. This allows for continuous testing of the well with different size chokes. Such a manifold arrangement is shown in Fig. 10.

Chokes. One or more chokes may be used in the testing equipment to restrict the flow of fluid from the formation being tested. By changing the chokes in the surface control equipment several times, valuable well completion data can be obtained during the flowing test.

A bottom-hole choke is used quite frequently to control the flow of fluid from the formation, especially where high pressures are encountered. This helps prevent sloughing of the formation due to a too rapid release of pressure from the well bore below the packer.

Fig. 11 shows a tool assembly used for running a subsurface choke. The precision choke nipple is installed in the upper part of the tool with a long strainer below it to help prevent plugging of the choke. The choke assembly is designed to allow a large flow from above if it becomes necessary to pump through the testing string. This is possible because of the by-pass around the choke.

This tool is installed in the testing string immediately above the tester. The outer case is constructed to correspond to drill pipe and tool joint diameters and has sufficient length to permit the use of elevators and rotary slips.

The hydraulic adjustable choke, Fig. 12, is another type of bottom-hole choke which helps provide protection for the formation and decreases the shock of the hydrostatic load on the packer. In addition, this tool has an automatic adjustment which allows the flowing test to be made through the regular full opening of the testing string after the controlled initial pressure release.

This tool is attached to the top of the tester so that all of the flow through the tester must pass through it. When the tester valve is opened, the choke diameter is ⅛ in. Formation pressure causes the mandrel in the hydraulic adjustable choke to move upward, increasing the flow passage progressively from ⅛ to 3/16 to ⅜ in. to full opening.

A mechanically adjustable bottom-hole choke is also available, in which the choke size can be changed during the test by rotating the drill pipe or tubing.

Safety joint. A safety joint is quite commonly used immediately above the packer to provide a means for detaching the drill pipe and testing tools from the packer and anchor in case one or both become stuck and cannot be removed from the well. Several types of safety joints are available. Usually rotation of the drill pipe, either right or left, is required to disengage the safety joint.

It is desirable that a safety joint be so constructed that right hand rotation of the drill pipe is needed to disengage it, so that no other threaded joint in the string will be unscrewed. It is also desirable that the safety joint be able to transmit rotation of the drill pipe during ordinary operations of the testing procedure so that it will not be broken accidentally.

The safety joint shown in Fig. 13 meets these requirements. The design of this tool utilizes a left hand thread, the male and female parts of which are splined together to help prevent unscrewing by ordinary drill pipe manipulation during the test. However, if it becomes necessary to back off the safety joint, a combination of right hand rotation and vertical movement of the drill pipe easily unscrews the joint.

This tool also has a built in by-pass, which acts as an auxiliary to the by-pass in the tester for equalizing pressure above and below the packer before unseating it.

Jar. A rotary jar is frequently used above the safety joint and packer. The jar is used to provide a "stretch" in the drill pipe. Releasing the stretch suddenly at the lower end of the pipe will deliver a powerful blow, or "jar," to help loosen the packer and anchor if either or both should become stuck.

Jars are made to operate by the sudden release of hydraulic pressure after a short travel of a piston or by a mechanical holding and releasing mechanism. Operation of the jar usually requires only a sufficient pull on the drill pipe to cause the releasing mechanism to function. Fig. 14 shows the operational sequence of a hydraulically actuated jar.

Cushion. The drill pipe or tubing is sometimes partially or completely filled with water as the testing string is lowered into the hole. This procedure is used when a high pressure and a high rate of production is expected from the formation being tested. The hydrostatic weight of the water column acts as a "cushion" and holds a back pressure against the formation when the tester valve is opened. This helps protect the formation from damage that might be caused if the release of pressure in the well bore below the packer is too sudden or if the rate of production from the formation is too fast.

A water cushion is also used to help protect the drill pipe or tubing from collapse. The cushion reduces the hydrostatic pressure differential from the outside caused by heavy mud or excessive depth, or both. It also helps protect the packer from extreme pressure differentials under these same conditions.

The same protection may be obtained in both cases by use of a pressurized inert gas.

TO BE CONTINUED

The conclusion of this article will appear in next month's issue of the *The Petroleum Engineer*. The second part will deal with formation testing classifications, open-hole and cased-hole testing techniques, pressure chart analysis, and recently developed techniques of formation testing.

GLOBAL NOTEBOOK

INDIA
INVITES OIL CAPITAL

EDWARD V. CORPS, *Independent Consultant, London, England*

The Indian Shield dominates the face of India and is surrounded by sedimentary basins. India's three producing fields (Digboi, Nahorkatiya-Hugrijan, and Moran) are located in the far northeastern reaches of the country. Exploration has shown some oil in the Cambay area near Bombay.

International industry turns attention to new workable laws and attractive prospects

DRILLING FOR OIL in India began in 1866. The prolific oil seeps hidden in the thick forests of the province of Assam, in the far northeastern corner of the country, were known long before. They are graphically described in the diaries of the pioneers who explored the jungle routes that lead eastward into Burma and China in the early years of the 19th century.

In 1865, H. B. Medlicott of the Geological Survey of India was deputed to investigate the coal deposits of Assam. At the same time he examined the oil shows, and in his report he recommended the drilling of some test wells to test the oil possibilities. This suggestion was taken up by the Calcutta firm of Stewart McKillop, who drilled the first well at Jaipur, not far from the oilfields later discovered at Digboi and Nahorkatiya. They continued with some wells on the Makum-Namdang structure, near Margherita, but only small quantities of oil were found. Owing to the absence of transport facilities prospecting was discontinued, to be resumed 20 years later. At that time the rights over the area had passed to the Assam Railways and Trading Company, who was mining coal. They drilled several wells in the Margherita area, ranging from 500 to 1000 ft, and obtained enough production to cause them to put up a small refinery. Output rapidly declined, however, and their attention was drawn to Digboi.

The engineers of the company were building a railway line to link their coal fields at Ledo to the Brahmaputra River in 1882, when they were impressed by the oil shows to be seen at Digboi. Legend has it that an elephant employed on the work returned to camp one evening with its feet soaked in oil. It was decided to test the structure, and oil was found in the first well in 1890.

Discovery well at Digboi, completed at 662 ft in 1890, was drilled by The Assam Railways and Trading Company. With initial production of 5 bbl per day, the well produced until 1927.

Geology

Geologically, India is dominated by the Indian Shield, a stable block composed of very ancient rocks, most of which have been subject to great crushing and metamorphism. The shield forms the southward extending peninsula of India, and there is a tongue which stretches northeastward into Assam, breaking through the sediments and alluvium of the Brahmaputra and Surma valleys in the form of the Shillong Plateau and the Mikir Hills. On the shield itself there are occasional narrow strips of Mesozoic and Tertiary sediments along the coastal regions.

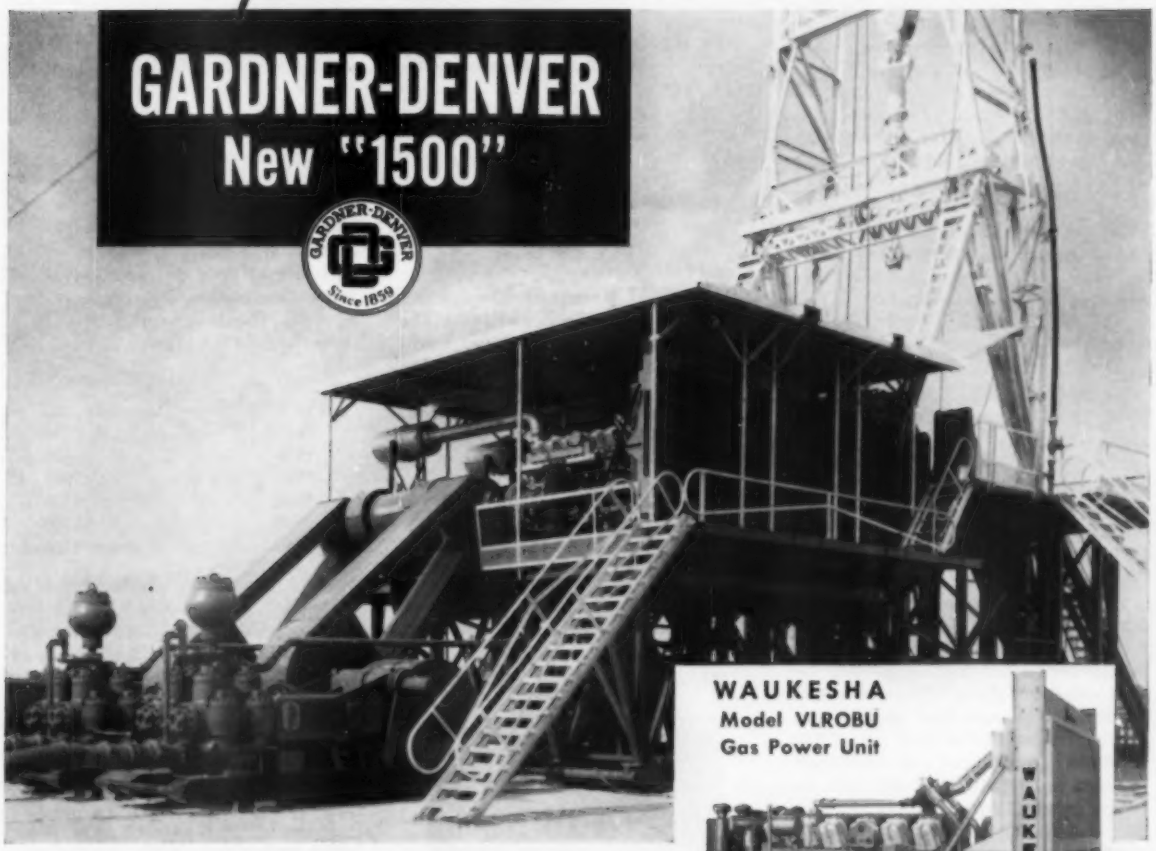
To the west, north and east of the shield, and between it and the intensely folded Himalayan range, are the sediments of a large depositional gulf, occupying in general what are now the broad river valleys of the Indus, Ganges, and Brahmaputra, and extending into the river system of the Meghna of East Bengal and the Irrawaddy of Burma.

In a review of the oil prospects of India, A. M. N. Ghosh, of the Oil and Natural Gas Commission, estimates that there are about 400,000 sq miles of sedimentary basins in India where there are oil possibilities. These basins contain marine and fresh water sediments ranging from Jurassic to Recent.

Possible Oil-Bearing Sedimentary Basins of India

Location	Area in sq miles
Assam (including Tripura and Manipur)	30,000
West Bengal Basin	30,000
East Punjab, Jammu, Kashmir	50,000
Rajastan	46,500
Cambay-Cutch	68,500
Ganga Valley	142,000
Madras Coast	17,000
Andhra Coast	9,500
Travancore Coast	6,000
Andaman and Nicobar Islands	3,000

three WAUKESHAS *power*



B. L. McFarland Drilling Co., of Midland, Texas, first to drill with new "1500" Gardner-Denver rig.

With its drawworks rated 1500 input hp, this new Gardner-Denver "1500" rig is fast, economical and efficient for drilling to 20,000-ft. with 4½-in. O.D. drill pipe. A total of 8 forward and 2 reverse speeds to the drum; 4 forward and 2 reverse speeds to the rotary table can be obtained. Compounds and drive arrangements for this drawworks are limited only by customer requirements. The McFarland rig shown includes a 142-ft. 1-million lb. capacity drilling mast, one Gardner-Denver RT-27½ rotary table, and two Gardner-Denver GR-GXR mud pumps. Powering the rig are three Waukesha Model VLROBU Waukesha Gas Power Units with tremendously powerful, rugged 12-cylinder 5788 cu. in. engines, each developing 700 continuous duty hp, well known for their long-life dependability and economy in oil field service.

WAUKESHA
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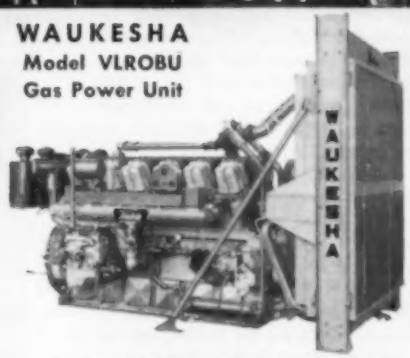

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Petroleum Legislation

After India became self-governing in 1947 new regulations were formulated and these were issued as the Petroleum Concession Rules of 1949. Although these, in turn, have recently been superseded they are the rules which still govern the current concessions for oil operations in India.

Under these 1949 rules foreign companies are admitted, but the government has the right to insist on Indian participation to an extent to be settled in negotiation beforehand. There is no settled form which this participation must take. The Assam Oil Company, a Burmah Oil Company subsidiary which discovered promising oil production at Nahorkatiya in 1953, has been required to develop the discovery through a new company, to be incorporated in India and to include 33⅓ percent Indian investment. This company is Oil India Private Ltd. with a nominal capital of $105 million, and the 33⅓ percent has been taken up by the government of India itself.

In the case of Standard-Vacuum the government entered into a joint venture, contributing 25 percent of the exploration expenditure year by year up to a maximum of $5.2 million. Upon the discovery of oil in commercial quantities, the conditions for a mining lease to develop the production will be negotiated.

As their exploration of areas held under these rules has progressed, both Assam Oil and Standard-Vacuum have applied for further concessions over vacant areas, but the government has so far declined to grant these applications. In the original version of the 1949 Rules a mining lease was obtainable for a period of 30 years, followed by renewal for a further period of up to 30 years at the holder's option. This condition was amended in 1955, when the initial period of the lease was reduced to 20 years, and renewal thereafter was at the government's discretion.

The Petroleum Concession Rules of 1949 were replaced by the Petroleum and Natural Gas Rules 1959 which came into force on November 25, 1959. Introducing these rules, the government emphasized that they were intended to attract much-needed foreign capital to boost oil production from the present 10,000 bbl per day (65,000 bbl per day when the refining capacity becomes available) to meet a target of 280,000 bbl per day demand in 1966. The new rules are shorter, and although the conditions for operation are defined the emphasis throughout is on the settlement of final terms by negotiation with the government. To encourage speedy exploration, license fees have been greatly increased and the period allowed for exploration has been reduced. Government's very wide powers to regulate operations in order to prevent waste have now been included for the first time.

It has been explained that those regions in which the government's own Oil and Natural Gas Commission has found oil and gas are excluded from the areas for which foreign companies may apply. March 31, 1960, was set as the date for foreign oil companies to indicate interest in exploration under the new laws. To date there has been no official news of what approaches have been made, but Caltex, Conorada, Continental, ENI, Gulf, Standard of Indiana, Stanvac, Shell, and Japanese interests have all been named in press reports.

Indian Oilfields

Digboi. Oil in commercial quantities was discovered at Digboi in 1890. The Assam Railways and Trading Company's Well No. 1 was begun in 1889 and completed at 662 ft in November 1890. Initial production was 5 bbl per day, and the well continued to produce until 1927. In 1899 the Assam Oil Company was formed to take over the oil interests of the A. R. and T. Company, and by 1917 production had reached 450 bbl per day. In 1921 the Burmah Oil Company took over management of the Assam Oil Company.

The field is situated in the extreme northeastern corner of Assam, about 600 miles from Calcutta. It is located on a long, narrow, fairly tightly-folded anticline, trending WSW to ENE. The north flank is steep, vertical in places, and is bounded by a thrust fault. This fault is the Naga Thrust, which can be traced for nearly 250 miles along the foothills of the southeastern border of the Brahmaputra alluvial valley. There are 24 separate productive sands of Miocene age, belonging to the entire Tipam Sandstone Stage, and an underlying thin development of the Surma Series. Production is found at all depths from just below the surface down to 6750 ft. More than 1000 wells have been drilled, of which 500 are on production at a given time. Most of the wells are of poor caliber and half the production comes from no more than 30 wells. The daily average production from the field has been:

Year	Bbl per day
1900	less than 100
1910	240
1920	400
1930	3000
1940	4500
1950	4700
1959	about 4500 (est)

and the cumulative production at the end of 1959 was around 60 million bbl.

All types of control have been found; gravity, dissolved gas drive, gas-cap expansion and edge-water drive. Most of the artificially-lifted production is by gas lift, with a small amount, mainly from shallow wells, by pumping. Total recovery from the field is expected to be about 80 million bbl.

Nahorkatiya-Hugrijan. For many years exploration in the Brahmaputra Valley concentrated on testing the numerous anticlines which line the foothills on the southeastern border of the valley in the hope of finding another Digboi, but without success. In 1952 a test well was begun on the north side of the Naga Thrust at Nahorkatiya, 20 miles west of Digboi, where geophysical work had outlined a structure. This well was completed in 1953 at 11,715 ft, and found oilbearing sandstones in the Barail Series from just above 10,000 ft. These beds are of Oligocene age, stratigraphically just below the productive range at Digboi.

Development of this field has revealed a rather complicated structure, consisting essentially of gentle folding broken up by faults, some of which have acted as barriers to fluid migration. Five main producing zones have been identified, ranging from 9000 to 13,000 ft. By March 1960, 57 wells had

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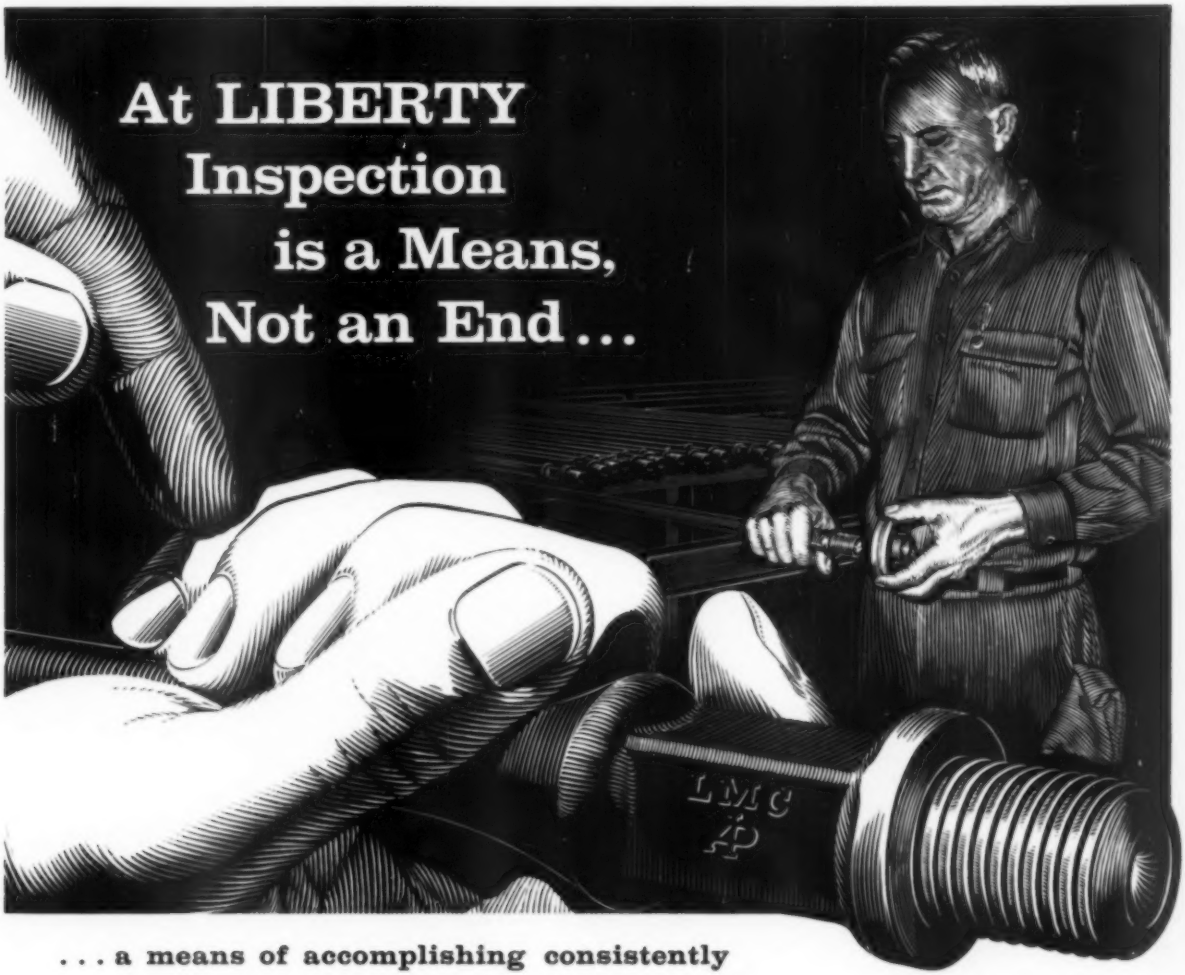
The Author

Edward V. Corps, BA, FGS, was graduated in geology from Cambridge University in 1930 and immediately joined The Burmah Oil Company. He spent 26 years with this company in Burma, India, and Pakistan working as field geologist, petroleum engineer, exploration manager, and company manager. He has served on government-sponsored committees in India and Pakistan and as vice president of the Mining, Geological and Metallurgical Institute of India. He is now an independent consultant in London.



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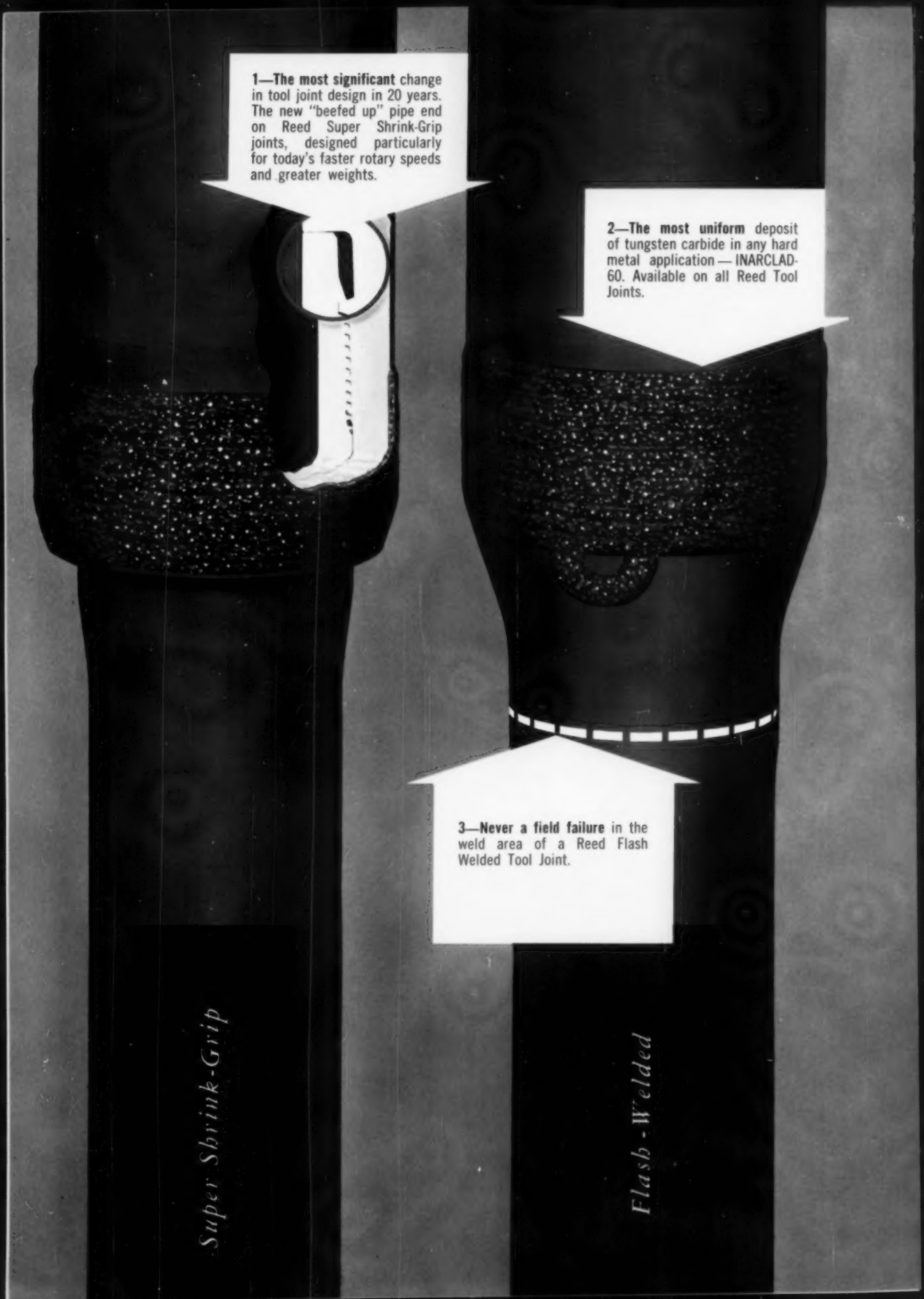
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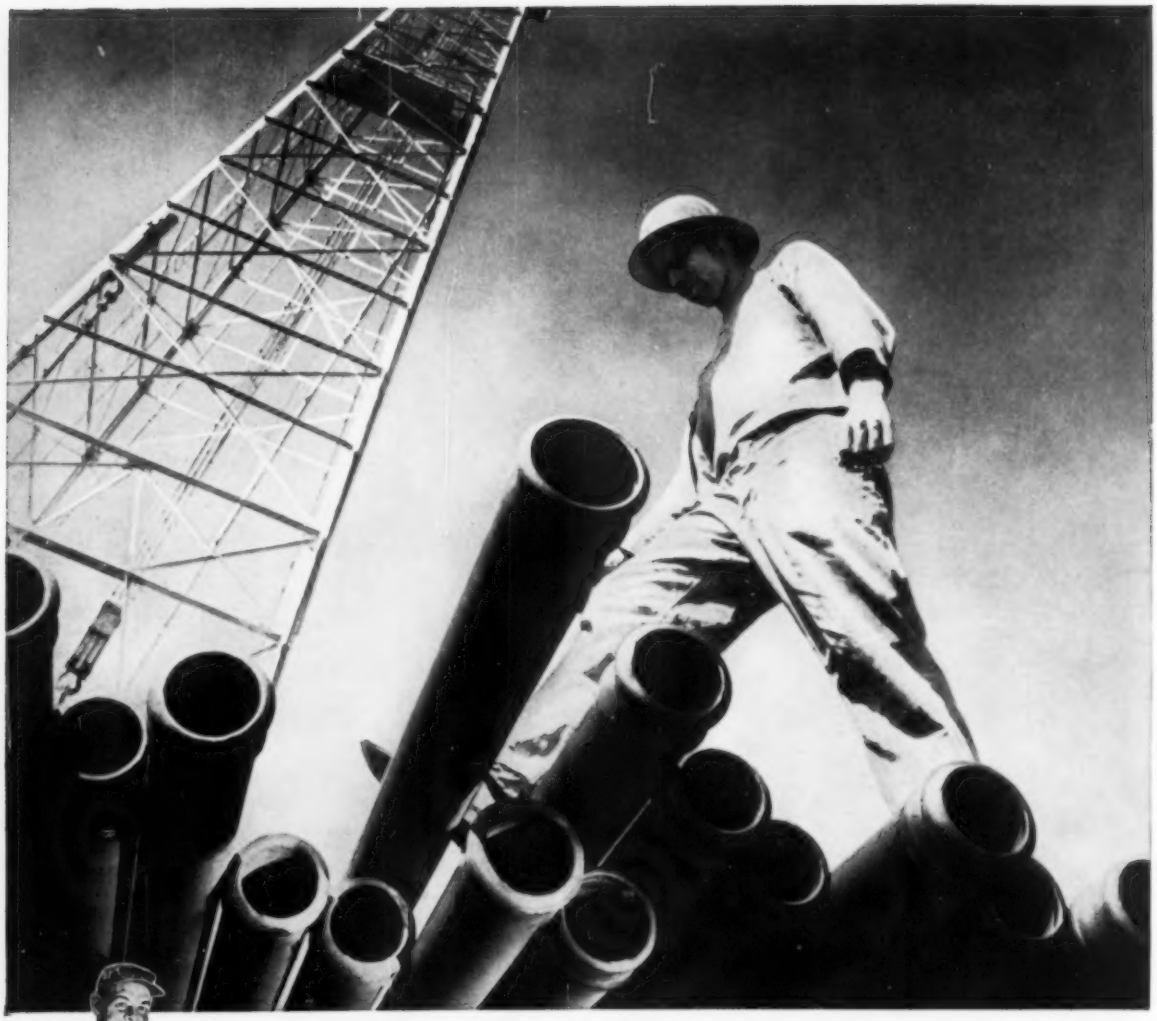

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been completed, of which 47 are producers, 2 gas wells, and 5 dry holes. Productivity varies, but many wells have flowed over 2000 bbl per day on open test. An average daily production of about 300 to 700 bbl per well is expected under controlled conditions.

At present there is limited production to help keep the Digboi refinery up to maximum throughput, the remainder being shut in awaiting the new government-owned refineries to be erected at Nunmati (near Gauhati) and Barauni. The potential output of the Nahorkatiya-Hugrijan and Moran (see below) fields is estimated at 60,000 bbl per day.

Moran. Following the Nahorkatiya discovery a test was drilled on a similar sub-alluvial structure at Moran, 25 miles further west. The first well was completed at 13,739 ft in 1956, having found oil at about 11,000 ft. The structure is thought to be similar to that of Nahorkatiya. Well No. 1 is believed to be located on a large primary uplift whose northwestern flank has been faulted. A number of faults, breaking up the field into separate blocks, are suspected. Formations have a low dip and exhibit considerable lateral variation. Production is found in Barail sands equivalent to those of Nahorkatiya. By March 1960, 12 wells had been drilled, of which 7 are producers, 1 is a gas well, and 4 are dry holes. The caliber of the wells is similar to Nahorkatiya, but production is shut in awaiting refinery capacity.

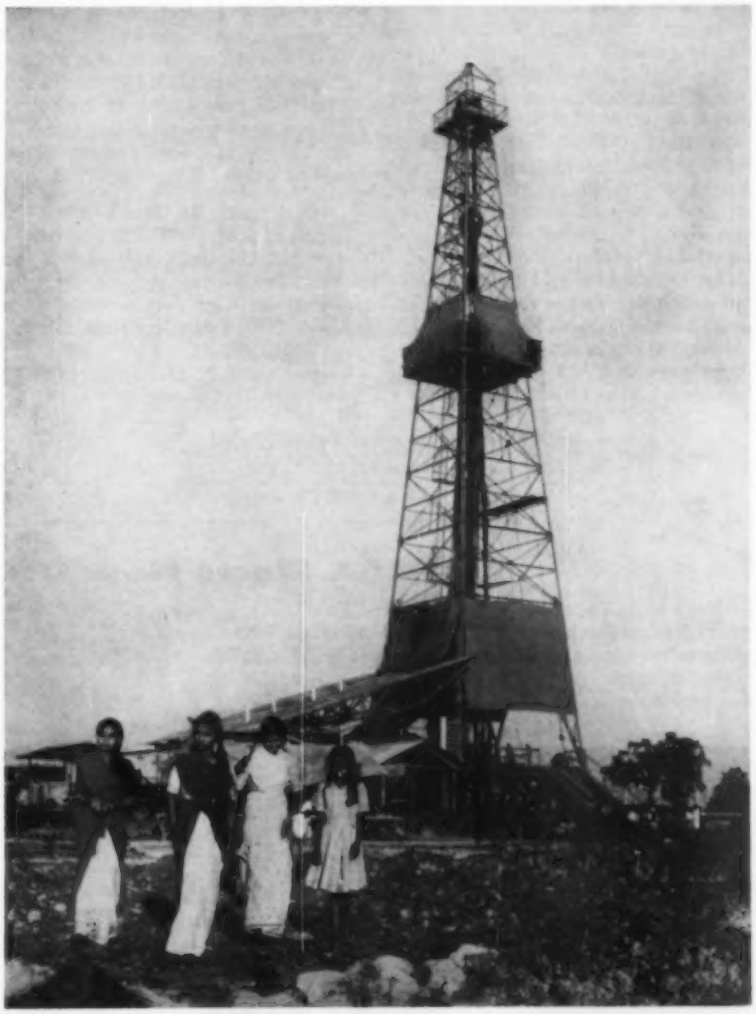
Badarpur. In 1912 the Badarpur Tea Company drilled some wells near the oil seeps at Badarpur, an important rail junction in the Surma Valley of Assam, 300 miles northeast of Calcutta. The Badarpur Oil Syndicate was formed, and in 1915 its operations were taken over by The Burmah Oil Company who proceeded to develop a small oil field. The structure is a small faulted anticline about 1 mile long by ¼ mile wide, in which production was obtained from sands down to 1500 ft in the lower part of the Surma Series and the underlying Barails. Some of the wells gave very promising initial yields but decline was rapid and the oil was accompanied by large quantities of water. The field ceased to produce in 1933, having given a total of a little more than 1½ million bbl.

The Oil and Natural Gas Commission

In 1945 a post of Petroleum Engineer was created in the Geological Survey of India, and later the Ministry of Natural Resources and Scientific Research decided that a separate Petroleum Exploration Division should be set up. In the fall of 1955 a delegation visited the USSR and other European countries to observe the working of state enterprise in oil exploration, to study the status of the oil industry in these countries, and to see what equipment was available and what facilities there were for training Indian personnel for oil exploration. As a result of this visit the Oil and Gas Directorate was set up at the end of 1955 to initiate prospecting for oil and natural gas on a wide scale.

A team of Soviet experts and German and American consultants was invited to India to report on the oil prospects of the country. The Soviet group, who stayed five months, submitted a report which, in addition to the purely technical aspects of the problem, embodied a comprehensive program of oil exploration for the Second Five Year Plan. It dealt with the phasing and interrelation of the various operations, and set up targets for geological, geophysical, and drilling work. It recommended the formation of an autonomous Commission to permit the expeditious functioning of the Oil and Gas Directorate.

Accordingly a three-man Oil and Natural Gas Commission was established on August 14, 1956. It comprises separate directorates for geology, geophysics, and drilling operations. On October 15, 1959, the "Oil and Natural Gas Commission Act, 1959" converted the Commission from a Government Department into a statutory body, which will enable it to function without the constant regulation of its day to day affairs inseparable from governmental working. The Act provides "for the establishment of a Commission for the development of petroleum resources and sale of petroleum and petroleum



Moran Well No. 6 was drilled by Assam Oil Company (now Oil India Private Ltd.) in the Moran field, India's third commercially successful field.

products produced by it and matters connected therewith."

From the beginning the Commission has had the close collaboration of Russian and Rumanian experts, who have also helped to train Indian personnel. It began oil exploration in 1956 with 13 geological parties, 5 gravity/magnetometer parties and one seismic party. Today the Geological Directorate has 20 field parties with a strength of 125 geologists and 50 surveyors. The Geophysical Directorate has 8 gravity/magnetometer, 8 seismic, and 2 electric logging parties, employing in all 150 geophysicists and 60 surveyors.

The Commission has at present eight deep drills, 3 Rumanian and 5 Russian, with a capacity of 15,000 ft. They are manned by Rumanian and Russian experts, with Indian understudies. There are also four 4000-ft structural drills, and two 6000-ft outfits are on order from the USA. The Commission has the assistance of some 100 foreign experts.

In India's Second Five Year Plan, for the period 1955 to 1960, $63 million was allocated to the Commission for oil exploration, and a production target of 100,000 bbl per day by 1962 was set. The Third Five Year Plan, 1960 to 1965, has allocated $420 million, and a revised target has been set to meet a demand of 280,000 bbl per day by 1966. During this period the number of geological field parties is to be increased from 21 to 25, gravity-magnetometer parties from 14 to 18, and seismic parties from 18 to 30. About 200 exploratory wells, 90 structural wells, and 300 production wells are envisaged, and it is expected to have about 50 rigs in operation at the end of the period.

Exploration

The Burmah Oil Company, and its subsidiary, the Assam Oil Company, have drilled over 300 test and information wells in India. The company has developed the only oil fields at present known; Digboi, Badarpur (abandoned), Nahorkatiya-Hugrijan, and Moran. Apart from extension drilling in the Nahorkatiya-Hugrijan and Moran areas, it has no exploration in progress at the present time as it has so far been unable to obtain further concessions.

The Standard Vacuum Oil Company completed its joint venture agreement with the government of India on December 24, 1953, and began prospecting (as the "Indo-Stanvac Petroleum Project") in an exploration license area covering 10,000 sq miles in the Bengal Basin. Surface geological mapping and a comprehensive program of aero-magnetic, gravity, and seismic surveys have been carried out, and test drilling began in 1957. By March 1960, 8 tests had been drilled, all dry holes.

The Oil and Natural Gas Commission has reported results on the following test wells:

Jawalamukhi 1: Over 8300 ft. The well is sited 1000 ft above the Jawalamukhi Temple, where a gas seep feeds a sacred flame which has been burning for centuries. Gas shows have been reported at about 2900 ft.

Hoshiarpur 1: 11,480 ft. No shows reported.

Cambay (Lunej) 1: 7188 ft. Shut in. Oil zones reported 5492-5610, 5658-5697, and 5727-5756 ft. Commercial possibilities not yet evaluated.

Cambay (Malsoni) 2: Oil show reported at 5000 ft.

Vadsar (near Bombay): Gas and oil shows reported at 500 ft.

Sibsagar: 12,500 ft. Dry.

Sundernagar: Oil sands reported.

Cambay 3: Drilling

Cambay 4: Drilling

In addition the Commission has drilled a number of shallow borings, and is to explore areas at Ankleswar and Kim.

The Whitehall Petroleum Corporation prospected in India between 1920 and 1925. They drilled a number of test wells, none of which was successful.

Pipelines

Hitherto India has had no crude oil pipelines, the Assam Oil Company's 8000-bbl refinery being located on the Digboi field. Oil India Private Ltd., the company with government participation formed to operate the fields at Nahorkatiya-Hugrijan and Moran, is now constructing a 720-mile pipeline between these fields and the new government-owned refineries to be erected at Nunmati (Assam) and Barauni (Bihar). The contract for this line has been given to a German-Italian combine, Mannesman and ENI, and the project is to be completed in two stages. The first stage, 260 miles of 16-in. line to Nunmati, is due for completion this year, and the second stage, 460 miles of 14-in. to Barauni by September 1962. * * *

PESA Elects New Officers

The board of directors of the Petroleum Equipment Suppliers Association has elected Elliott Johnson and John G. Seiler as president and vice president, respectively, of PESA. Their combined oil industry equipment and service experience embraces 54 years.

Elliott Johnson

John G. Seiler

Election of Johnson and Seiler was at the annual meeting of PESA in Banff, Alberta, Canada. Other business on the agenda included the appointment of new district committee chairmen.

Elliott Johnson of Houston, Texas, is vice president-finance and general counsel of the Schlumberger Well Surveying Corporation. John Seiler of Louisville, Kentucky, is president of Tube Turns, division of the Chemetron Corp.

Johnson attended and received undergraduate and law degrees from the University of Chicago and later another law degree from the South Texas College of Law. Also, he took three years of accounting at Northwestern University.

Employed by Schlumberger since 1936, he has been active in various business, civic, political, and religious affairs. He is a member of various bar associations and fraternal organizations.

Seiler joined Tube Turns in 1930 and was appointed sales manager the following year. He became vice president at the beginning of World War II and general sales manager in 1945. He was named president of the company in May 1956.

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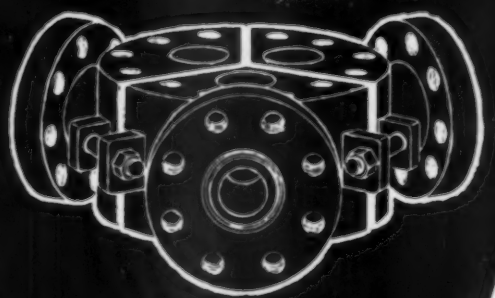

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Part 3

Simplified Log Interpretation

Charts used with radiation induction and guard logging tools give quick readings on deep investigations

TERRY WALKER, *Chief Formation Evaluation Engineer*
Welex, Inc., Houston, Texas

The previous two articles discussed the means of simplifying the proper choice of logging tools and the interpretation of the induction or guard tools in conjunction with FoRxo tool. The characteristics of the guard and induction tool, and the area of application of each were discussed in detail because the logging problems encountered are such that the user of the logs must understand these principles clearly. (See The PETROLEUM ENGINEER, May and June, 1960.)

ACCURATE RESULTS from any log depend upon an understanding of the particular section of the formation the device is responding to at a given point. The inter-bedding present in the majority of formations will, of course, affect the focussed curves even though the cross section may be quite thick. The detail given by the FoRxo with the induction or guard tool is such that the inter-bedding can be recognized and accounted for.

Vugular and fracture porosities present a difficult logging problem. If the fractures or vugs are extremely random the usual Archie saturation equation $S^n = Ro/Rt$ will not apply, as it was developed for intergranular porosity. However, when the fractures or vugs are small and interspersed, the intergranular condition is approached; and the equation can be applied.

In general, the neutron tool will give more reliable values of porosity than any other porosity tool for the fracture or vugular porosities, since the tool reading samples a larger volume of

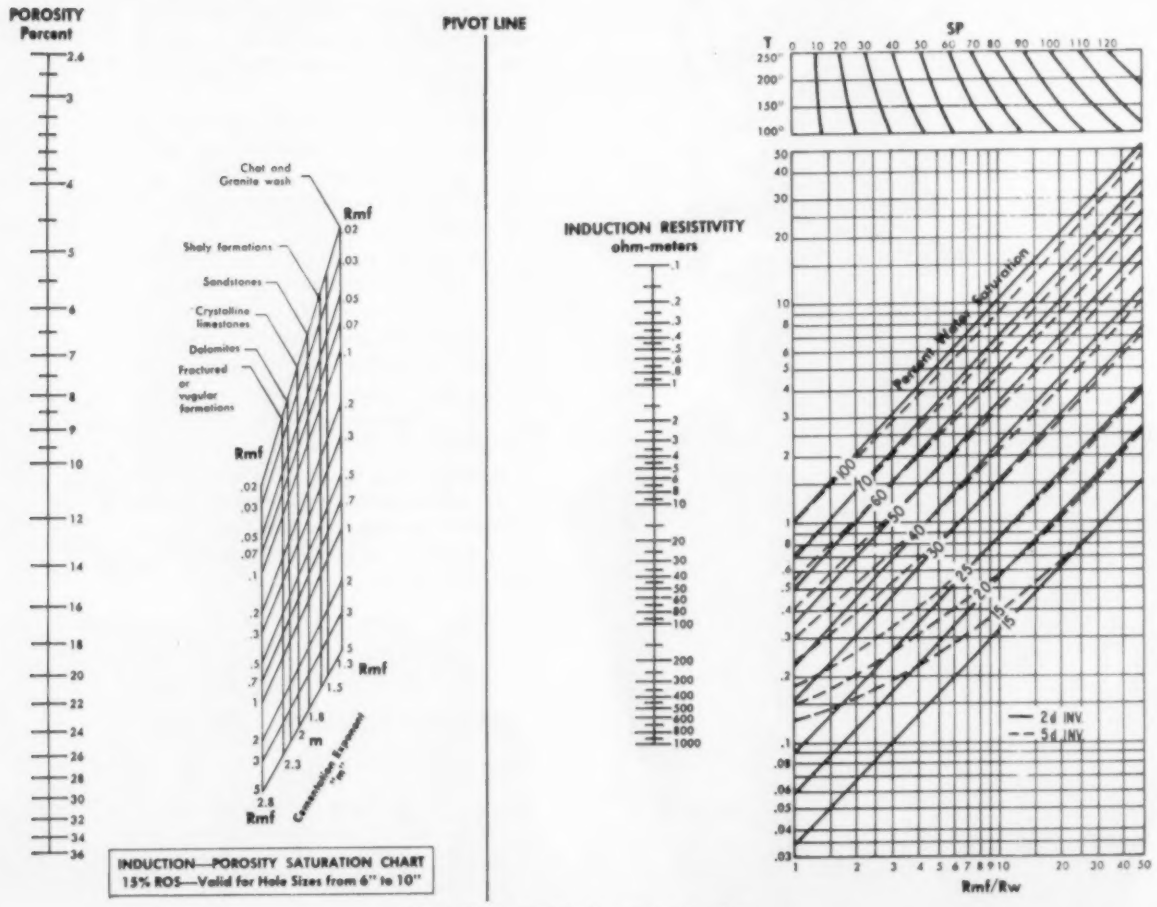

FIG. 1. Radiation-induction saturation chart.

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material. In addition to this characteristic, the response of the neutron tool with porosity is semi-logarithmic, thus giving excellent discrimination in the lower porosity ranges and as a result is widely used in many areas, even where intercrystalline porosity predominates.

The operating principles of neutron logging were discussed in Part 1 of this series in which it was shown that the tool is responding to the presence of hydrogen. As a result the tool's response can be related to porosities. The tool essentially is measuring the hydrogen present in a given volume around the tool so that the bore hole size has an effect.

The larger the bore hole, the more hydrogen will be near the tool in a fluid filled hole within the given volume and, therefore, the lower the reading for a given porosity. This effect, however, is taken into account in the porosity scales shown on the bottom of the neutron logs by showing scales for all bore hole sizes present in the well. So far as bed thickness effects are concerned, the neutron tool gives reliable values of porosity for zones which are of a thickness equal to or greater than two or three bore hole diameters.

The presence of shale in any formation of interest will, of course, affect any porosity tool, giving an indicated porosity higher than effective porosity. The present methods for taking into account the effects of the shale presence are only qualitative at best on any of these porosity tools. So it is with the neutron log porosities—in some cases more reliance must be placed on the interpretation in the clearer sections as indicated by the gamma curve.

Saturation Calculations

When the usual water base muds are used, either the induction or guard log is used for deep investigation reading, depending upon the expected Rmf/Rw value as discussed in detail in Part 1.

When the porosity is determined by means of other than resistivity measurements such as the FoRxo Log, calculations must be made to relate the porosity to F (formation factor) before saturation calculations can be made. It is also desirable to evaluate the possible effects of mud filtrate invasion on the resistivity log, either guard or induction. This requires an estimate of m (cementation factor) and a measurement of Rmf. Both values are then put into the calculations with the aid of the formation grid chart on the radiation-induction saturation chart as shown in Fig. 1 or the radiation-guard saturation chart as shown in Fig. 2.

To facilitate proper selection of m values, the grid is marked with appropriate rock descriptions which are readily available. The m value applicable to each type is shown at the bottom of the formation grid.

Application of these two values calculate a synthetic Rxo value on the pivot line in Fig. 1 and 2 (although no values are shown). The remainder of the charts is identical to the induction-FoRxo and guard-FoRxo saturation charts shown in Part 2 of this series (Fig. 2 and 3).

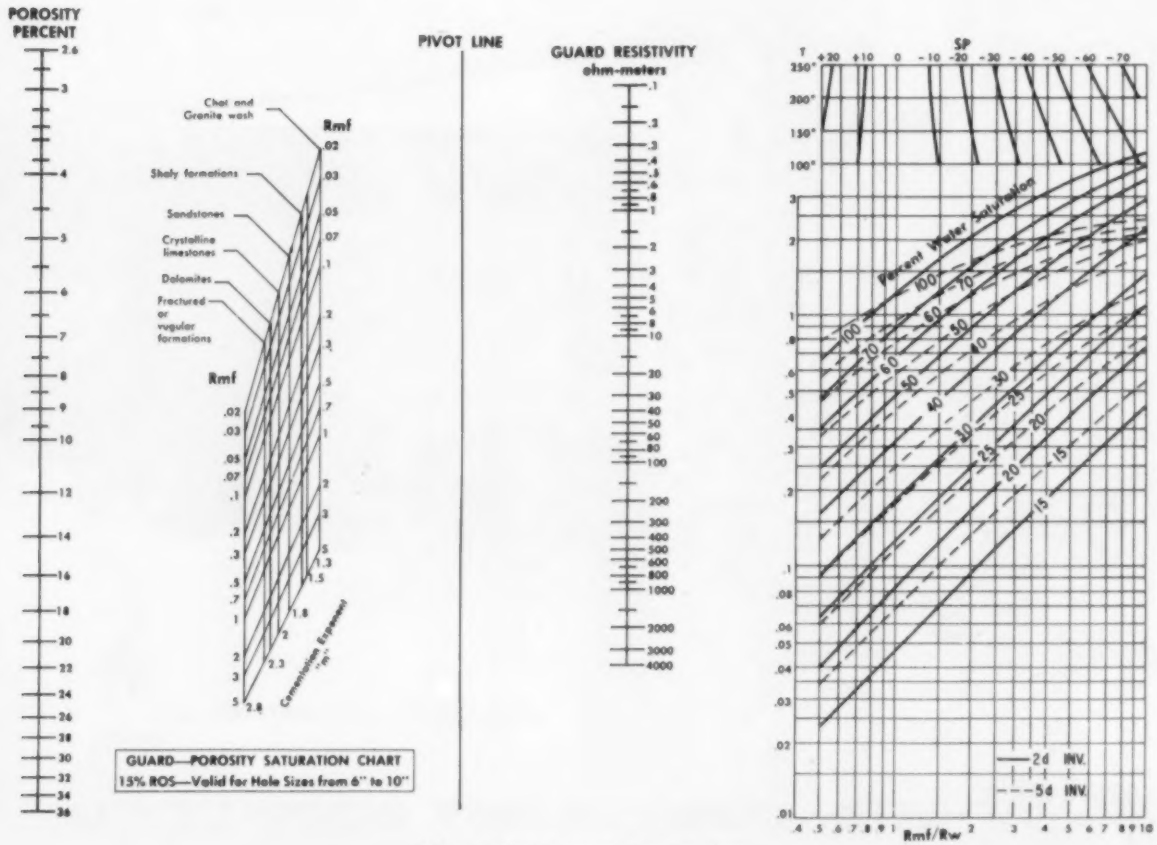
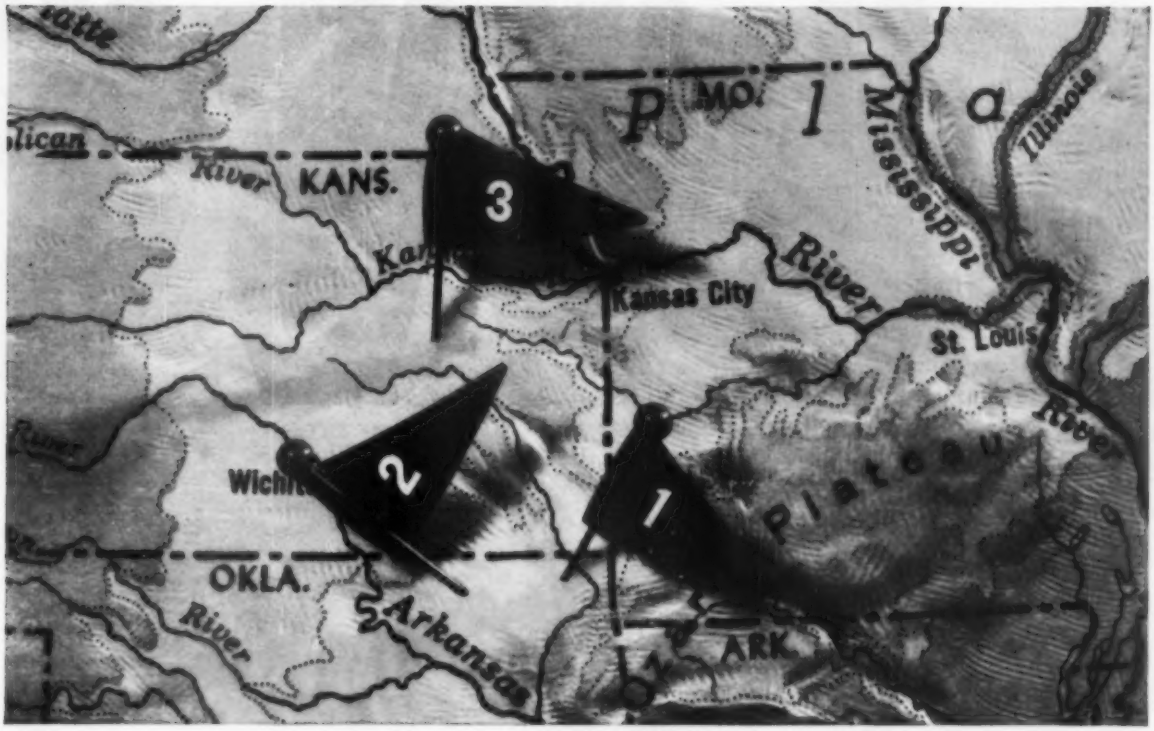


FIG. 2. Radiation guard saturation chart.



Hagan controlled solubility phosphates

STOP BARIUM SULFATE SCALE

Barium sulfate scale is a serious production problem in many mid-continent water floods and its appearance usually results in expensive workovers and mechanical cleaning jobs. However, barium sulfate scale *can* be stopped before it starts by proper treatment with Hagan's new 15-J Controlled Solubility Phosphate. Here are three projects that have put 15-J to work and are now saving $6 to $22 a day for each producing well being treated.

1 An oil field in Northeastern Oklahoma has been under water flood long enough for the high sulfate injection water to mix with the original formation water that contains barium, with scale-stuck pumps the result. When the pulling frequency increased to twice a month, a program of evaluating the commercially available scale inhibitors was initiated.

Three factors—performance, ease of feeding and total treatment cost—were used to select a single scale inhibitor for field-wide application. Hagan's 15-J scored the highest *in all three* categories. Treating cost of $2 per 1000 bbls. of water produced was so low that all wells pulled more than once every three months could be treated with 15-J.

2 In a nearby field, barium sulfate scale was recognized as a problem early in the life of most water floods. However, preventive treatment was considered too costly, due to the large volumes of water being handled (1000 BWPD). However, stripping costs mounted to the point that a thorough program of testing all known barium sulfate scale preventives was undertaken by the operator of the largest flood in this field.

Wells with a serious scaling history were treated for 3 months and *then taken off treatment entirely* as a double check on the continuing severity of barium sulfate scale build-up. Dosage was regulated by routine phosphate determinations made on the produced water. The operator soon established that all producing wells pulled more than once every 4 months could be economically treated regardless of how much water was being produced.

As a result of this complete field testing program, Hagan's 15-J Controlled Solubility Phosphate was selected for general use.

3 A water flood in Kansas' Flint Hill country developed a barium sulfate scale problem bad enough to require pulling some wells every 10 days.

The first well in this field selected for 15-J treatment made 400 BWPD and had a 110°F BHT. In the six months preceding treatment, this well was pulled 14 times at an estimated cost of $2800. This well operated continuously during the first six months of treatment with 15-J. Operating cost was reduced by over $2500—a saving of $14 a day.

For information on how Hagan's Controlled Solubility Phosphates can help you, write or phone the address below.

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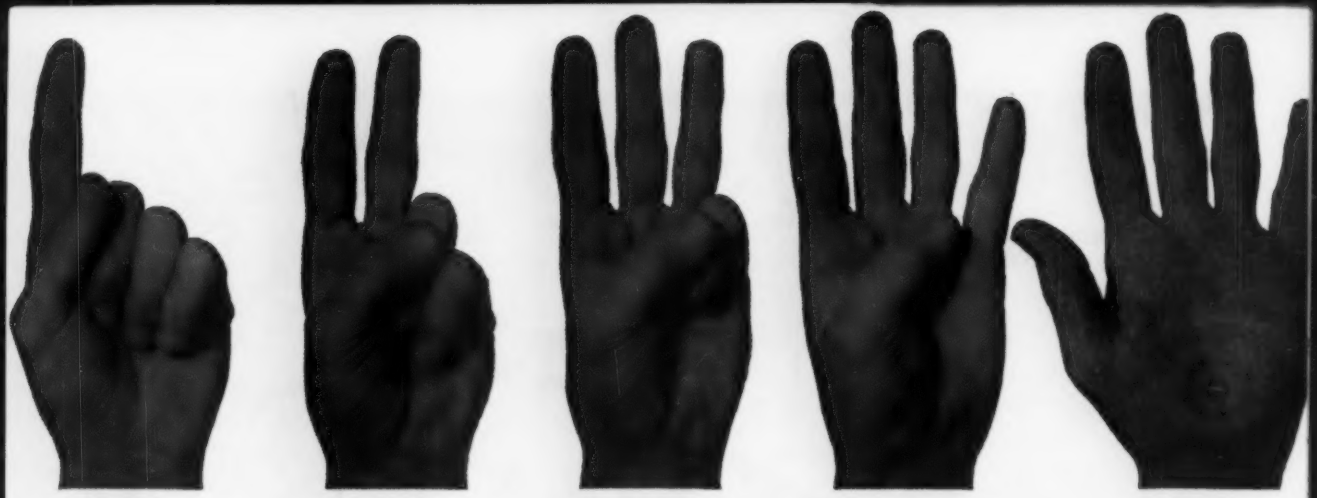

BETTER drilling rates in all types of muds: T-8, lime, gyp, and low pH, with varying amounts of oil.

BETTER (lower) barite requirements when substituted for oil in muds.

BETTER hole lubrication, in all types of muds, to reduce pipe sticking.

BETTER bit bearing life **even in high solids muds.**

BETTER geological interpretation and electrical logs; no fluorescence.

PLAN WITH BIT LUBE to drill 5 ways better . . .

WELL DONE WITH MAGCOBAR TECHNOLOGY . . . THROUGH PLANNED MUD PROGRAMS

MAGCOBAR PLANNED MUD PROGRAMS make the above statements facts, not claims. In high weight emulsion muds, for example, the Magcobar engineer properly substitutes Bit Lube® for some of the oil to cut drilling costs by reducing the amount of barite required. In a typical well, the oil content of the mud was allowed to drop from 11 to 5 per cent. Bit Lube was added to this 17.8 lb./gal. lime mud with these savings in barite:

	Sacks of barite per day	Cost of barite per day	Cost of Bit Lube per day	Cost of Oil per day	Total Cost per day
Emulsion (2 week average)	177	$409.76	$—0—	$74.03	$483.79
Bit Lube and Emulsion (3 week average)	52	120.38	122.43	8.25	251.06

NET DAILY SAVINGS WITH BIT LUBE: $232.73

Not only does Bit Lube give direct cost savings, but it also offers escape from costly pipe sticking, even in extreme directional holes. Bit Lube lowers the friction coefficient of the mud, to give over-all higher drilling mud performance. These savings can be added to those in the chart.

The skilled use of good products like Bit Lube to cut drilling costs is the heart of Magcobar Technology. Let the Magcobar engineer plan the mud program for your next well and this Technology will save for you all along the line.

WELL DONE WITH MAGCOBAR TECHNOLOGY . . . THROUGH PLANNED MUD PROGRAMS

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HOUSTON

Mat Dodson (left), Wilson Production Equipment Manager, checking equipment requirements on a well soon to go on the pump.

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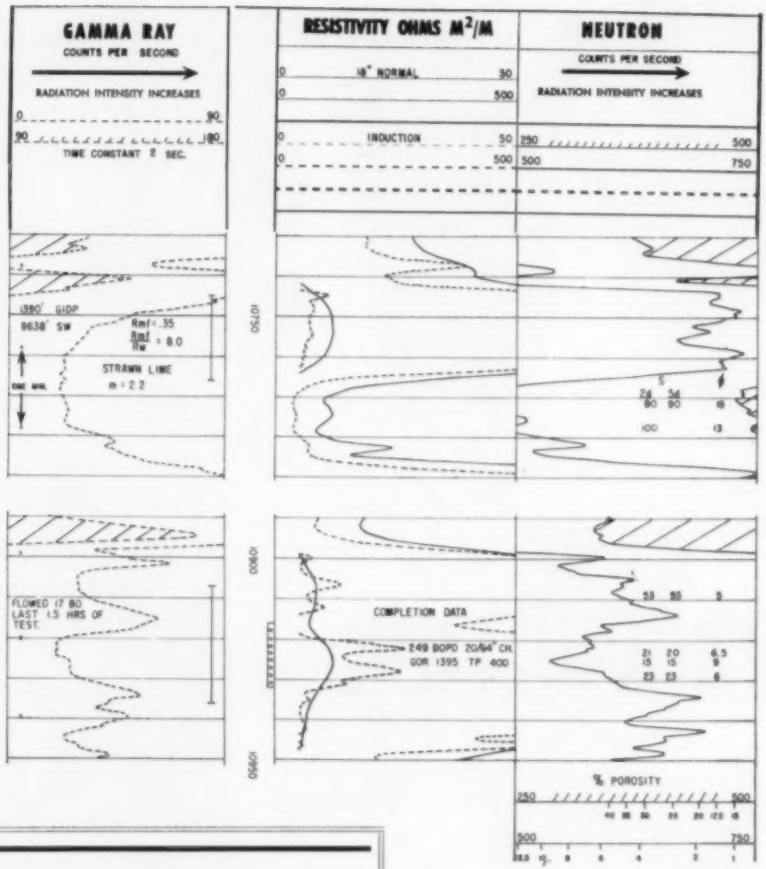
FIG. 3. Radiation-induction logging tool is applied in water-base muds with Rmf/Rw = 8x in the Strawn lime in Andrews County, Texas. Upper zone calculations indicate water productions verified by drillstem test. Lower zone calculations are also in accordance with test and completion results.



Radiation-Induction Logging

Fig. 3 shows the application of the radiation-induction logging tool in water base muds with Rmf/Rw = 8 in the Strawn lime in Andrews County, Texas. The upper zone calculations indicate water production as verified by drillstem test. The lower zone calculations are also in accordance with test and completion results. At 10,908 ft the calculation of 55 percent water in the 5 percent porosity is as would be expected — the lower porosity would have a higher water saturation because of capillary effects.

From 10,920 to 10,930 ft the calculated water saturation is considerably lower in the higher porosity. However, below 10,950 ft the calculated water saturations are high again but in relatively good porosity — which would be interpreted as a possible transition zone from oil to water.

Radiation-Guard Logging

Fig. 4 shows the radiation-guard log over the Arbuckle section of Russell County, Kansas, drilled with a low resistivity mud — Rmf/Rw = 1. This well is a field development well and the guard was run in the open hole and the radioactivity log was run after casing was set. This procedure results in a saving of rig time on the development wells but still gives the same complete information as on the initial wells in the field. In this case, the pipe was bailed dry before the radioactivity log was run.

Detailed saturation calculations are tabulated on the log along with po-

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rosity values from the scale at the bottom of the log. Also shown are the open hole tests and completion information.

Summary of Series of Articles

The purpose of this series of three articles is to show that by planning the logging program the maximum amount of information can be obtained from the logs. The use of the Simplified Log Interpretation allows saturation and porosity determinations quickly and easily. The principles upon which the the approach are based are not new, but the presentation of the method shows the logic and reason of log interpretation without laborious calculations from equations which at times obscure the effect of the various factors involved.

The log presentation also presents the log curves in such a manner that the effects of bed thickness, inter-bedding, shaliness, etc., can be taken into consideration by the user with reliable results. Also the saturation charts are presented so that all of the variables are shown on the applicable chart and the effects of the variations on the calculated saturations can be easily determined. ★ ★ ★

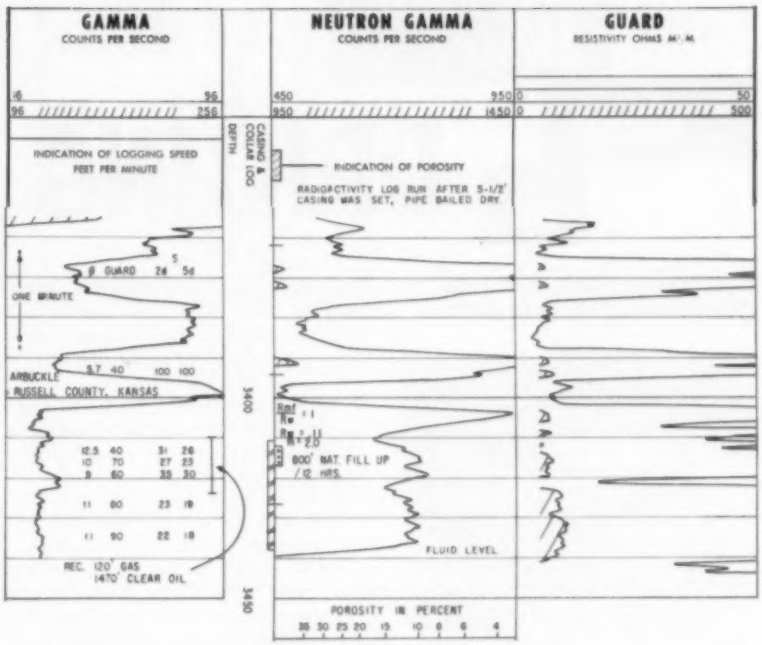

FIG. 4. Radiation-guard log over the Arbuckle section of Russell County, Kansas was drilled with a low resistivity mud, Rmf/Rw = 1. Well is a field development well and the guard log was run in the open hole, then the radioactivity log was run after casing was set.

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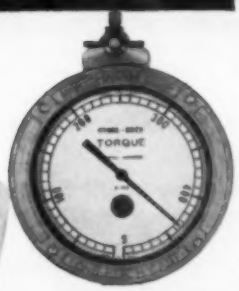

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What's doing in DRILLING

Dual Drilling Mast Trailer Rig Will Operate in Spanish Sahara

Photo courtesy Continental-Emsco

Extreme portability of a dual trailer drilling mast rig will provide Falcon-Seaboard Drilling Company ready transportation to well sites in the Spanish Sahara.

Remaining question of transportation was answered by a decision to beach the entire rig and camp assemblage on the harborless coastline by means of Navy-type landing craft. Falcon-Seaboard has an 18-month contract with Gulf Oil Corporation to drill the first wildcats in that country.

Before going aboard a freighter, the rig was assembled and set up in its entirety at the Houston plantsite — not only with the necessary drilling equipment, supplies, and spare-parts inventories, but complete even to the living quarters for a 40-man crew.

To prevent any delay on the first location, it was readied for immediate service and every component checked. At the Port of Houston, it was loaded aboard a freighter bound for the Canary Island port of Las Palmas. There, it will be transferred to a landing craft for the short leg of the trip.

A bulldozer carried with the equipment will build a sand ramp to the landing craft, then the load will be rolled off on trucks and trailers, ready to move inland.

Rig was designed for high portability and completed on a whirlwind schedule of just 45 days from the drawing board through final assembly.

Unique design features include two "trailerized" slush pumps. Their chassis forms the base skids for operation during unloading. The drilling mast operates on dual trailers and travels with traveling block strung and rotary table in position. Nominal gross capacity of the mast is 350,000 lb.

In addition to the mast and slush pumps, major components include a drawworks with torque converter; sand reel and automatic brake; 17½-in. rotary table; hook, traveling block, and swivel. Rig will utilize 7000 ft of 3½-in. drill pipe.

Mud system includes two 150-bbl mud tanks, shale shaker, de-sander, and chemical mixer. One trailerized tank is included for transporting fluid mud, plus two skid-mounted water storage tanks and one dry-mud storage bin. Fuel will be carried in two 2000-gal skid-mounted fuel tanks. Two 7 by 32-ft tool houses also are provided.

To take advantage of air drilling possibilities in the water-poor country, rig is equipped with four portable compressor units and one booster.

Facilitating more efficient operation and trimming spare-parts requirements, Falcon-Seaboard has standardized engines. A total of eight twin diesel packages and eight single diesels is employed.

Camp facilities for the crews include 15 skid-mounted units, providing space for offices, sleeping quarters, dining and recreation, kitchen, food storage, bath-laundry facilities, and such utility services as water purification apparatus.

Added transportation facilities include four diesel trucks, two trailer floats, and a tread-type tractor.

First well will be drilled in the South of Spanish Sahara on one of two blocks, 47 or 51, held jointly by Gulf and Cepsa, a Spanish independent. Gulf and Cepsa also hold three blocks in the North, numbers 9, 10, and 16.

Two Drilling Platforms Readied in California

Drilling platforms Helen and Hilda are being readied for their participation in drilling operations in California offshore waters.

Helen is the first oil drilling platform to be erected on the offshore lease five miles west of Gaviota and 30 miles west of Santa Barbara held by Texaco, Monterey Oil Company, and Newmont Oil Company.

Hilda is the second drilling structure to be placed on the Summerland offshore lease of Standard-Western and Humble Oil & Refining Company. Hilda will be located about 1¾ miles from Hazel, Standard's first platform, which has been in operation since summer of 1958.

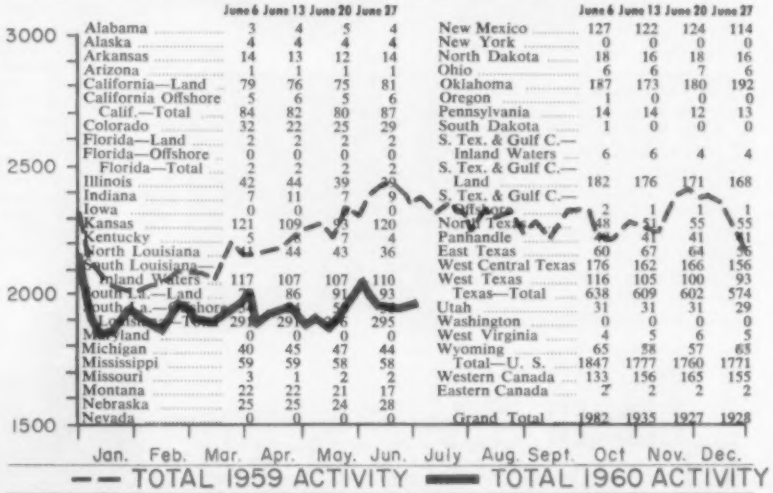
Pipelines are being laid to connect Hilda to Hazel, which in turn is connected to onshore storage facilities in Carpinteria.

Helen will be placed in 94 ft of water about 1½ miles offshore. Upper deck will stand 54 ft above the water at mean low tide, and its 20 steel legs will be

Rotary Rigs Operating in Oil Fields of United States and Canada

As reported to American Association of Oil Well Drilling Contractors by Hughes Tool Company.

	June 6	June 13	June 20	June 27
Alabama	3	4	5	4
Alaska	4	4	4	4
Arkansas	14	13	12	14
Arizona	1	1	1	1
California—Land	79	76	75	81
California Offshore	5	6	5	6
Calif.—Total	84	82	80	87
Colorado	32	22	25	29
Florida—Land	2	2	2	2
Florida—Offshore	0	0	0	0
Florida—Total	2	2	2	2
Illinois	42	44	39	39
Indiana	7	11	7	9
Iowa	0	0	0	0
Kansas	121	109	93	120
Kentucky	5	5	7	4
North Louisiana	43	44	43	36
South Louisiana—				
Inland Waters	117	107	107	110
South La.—Land		86	91	93
South La.—Offshore				
Louisiana—Total	291	291	291	295
Maryland	0	0	0	0
Michigan	40	45	47	44
Mississippi	59	59	58	58
Missouri	3	1	2	2
Montana	22	22	21	17
Nebraska	25	25	24	28
Nevada	0	0	0	0
New Mexico	127	122	124	114
New York	0	0	0	0
North Dakota	18	16	18	16
Ohio	6	6	7	6
Oklahoma	187	173	180	192
Oregon	1	0	0	0
Pennsylvania	14	14	12	13
South Dakota	1	0	0	0
S. Tex. & Gulf C.—				
Inland Waters	6	6	4	4
S. Tex. & Gulf C.—				
Land	182	176	171	168
S. Tex. & Gulf C.—				
Offshore	2	1	1	1
North Texas	48	51	55	55
Panhandle	40	41	41	41
East Texas	60	67	64	56
West Central Texas	176	162	166	156
West Texas	116	105	100	93
Texas—Total	638	609	602	574
Utah	31	31	31	29
Washington	0	0	0	0
West Virginia	4	5	6	5
Wyoming	65	58	57	63
Total—U. S.	1847	1777	1760	1771
Western Canada	133	156	165	155
Eastern Canada	2	2	2	2
Grand Total	1982	1935	1927	1928



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HALLIBURTON SAND SCREEN

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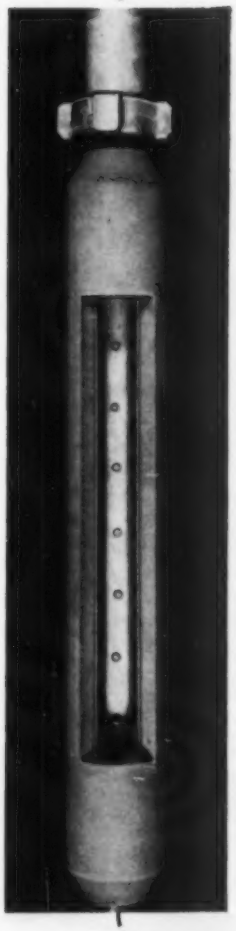


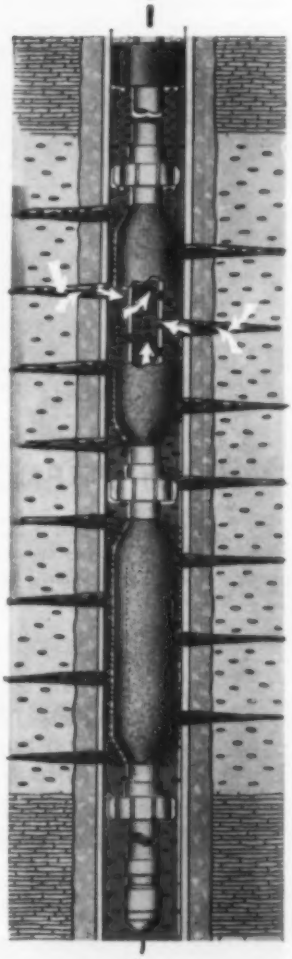
If you've been fighting a losing battle against formation sand, here's a new tool that may solve your problem.

We've cut a window in the Sand Screen pictured on the left to show you its construction. The regular screen is provided with conventional perforated tubing, as shown ... slotted type tubing is also available. That's the inside story, but the big news is on the outside.

The pre-formed screen, bonded to the inner tube, is made entirely of *consolidated sand* ... acts as a natural buffer ... is inert and compatible with most producing formations. The greater flow area provided by the sand facing tends to diffuse suspended formation sand, as shown on the right, rather than have it concentrate and restrict entry points. The bonding agent is a thermo-set resin, giving extremely high compressive, shear and tensile strength to the sand jacket — while still retaining 26% porosity over the entire face of the liner and a permeability of 23 darcies. Extensive field testing has shown beneficial results in wells with very difficult sand problems.

Halliburton Sand Screens are 6 ft. in length and are available in popular sizes for running in 4½", 5½", and 7" O.D. casing ... may also be run in open hole.

Your Halliburton man has complete details about this latest advancement from Halliburton Research ... he'll be glad to explain *Sand Screen* to you.



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imbedded 80 ft into the ocean bottom. The top drilling deck measures 130 by 138 ft and is large enough to accommodate 28 wells.

Depending on weather and tidal conditions, it is expected that work on the platform will take about 30 days.

Hilda will be settled on the ocean floor in 106 ft of water and will have facilities for drilling up to 24 wells, two at a time if desired. It will rise 217 ft from the ocean's surface to the tops of its derricks. Main deck will be 120 ft square and 58 ft above water level. Drilling operations are expected to begin latter part of August.

Trailer Rigs Use Aluminum For Portability in Arabia

Extensive use of high-tensile aluminum sections, instead of steel, marks the construction of two trailer-mounted rigs ordered by Arabian American Oil Company for slim-hole exploratory drilling in Saudi Arabia.

Each rig is mounted in a triple-deck trailer that carries all units except the mud system, pipe rack, and ramp.

Doghouse is carried on a cantilever at the side of the trailer and, together with the walkways, will remain in position during desert transport. All supply lines for fuel, water, and air — as well as the mud supply line — are built into the trailer. Accessories include a built-in standpipe, tong counterweights, tong line rollers, and highline sheave. Other equipment supplied includes hookblock and swivel.

Photo courtesy National Supply

Aluminum is used for eight stairways, the fuel tank, driller's doghouse, wire rope storage reel, racking platform, ladders, crown top platform of the mast and various structural members in the trailer assembly, with a weight-saving estimated at 20,000 lb. Although the extensive use of aluminum in place of steel is more costly, there are compensating advantages in operation, maintenance, and transportation.

With its mast folded down for transportation, each rig is 68 ft long, 16 ft wide over the wheel tracks, and 22 ft high. With the walkways and dog house in operating position, width is increased to 24 ft. Over-all weight of each trailer and its equipment is about 170,000 lb.

Drawworks, rotary table, and mast substructure are located on the second deck, which serves as the working platform.

Power drive group, consisting of three diesel engines, each equipped with a torque converter, and one slush pump, are located on the lower deck. On this level also is a centrifugal pump, used for general rig water service, washdown, etc. and a centralized control panel for the electrical equipment.

A 94-ft mast and an electric generator set, air compressor set, and the fuel tank, are located on the top deck.

Running gear for desert transport consists of two dollies, each having four wheels, complete with air brake equipment. On location, each trailer is supported on eight jacks based on aluminum bearing sills to keep ground pressure at a minimum.

Separate mud system includes a skid-mounted mud tank on which is mounted a shale shaker and mud mixer, with electric motors for each.

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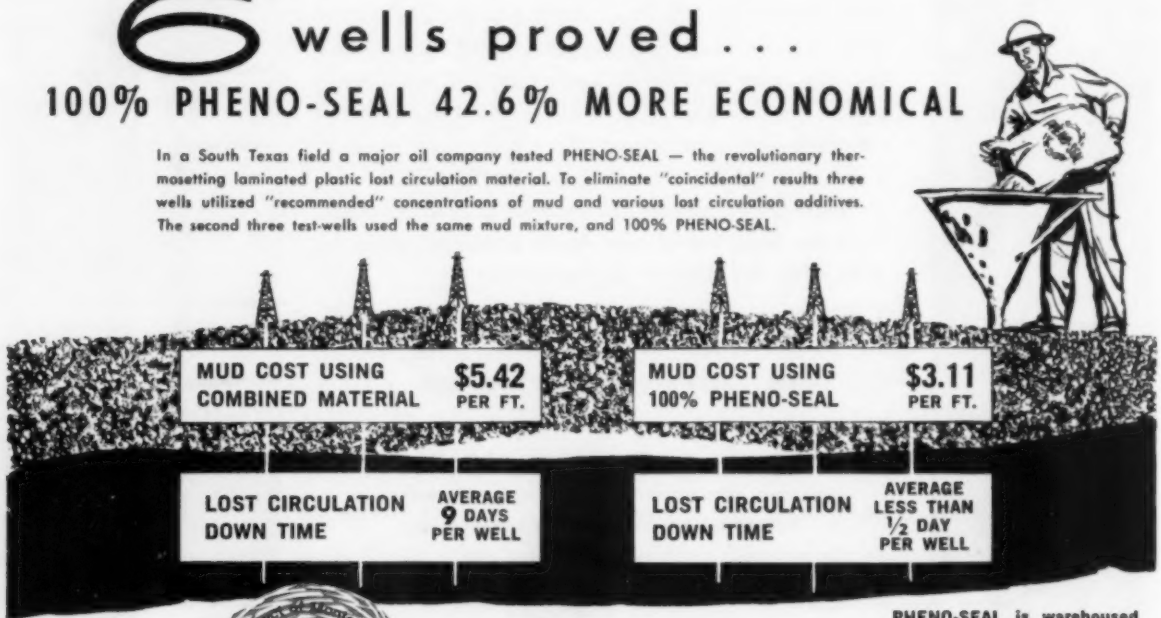
In a South Texas field a major oil company tested PHENO-SEAL — the revolutionary thermosetting laminated plastic lost circulation material. To eliminate "coincidental" results three wells utilized "recommended" concentrations of mud and various lost circulation additives. The second three test-wells used the same mud mixture, and 100% PHENO-SEAL.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AVERAGE 9 DAYS PER WELL
LOST CIRCULATION DOWN TIME
AVERAGE LESS THAN ½ DAY PER WELL

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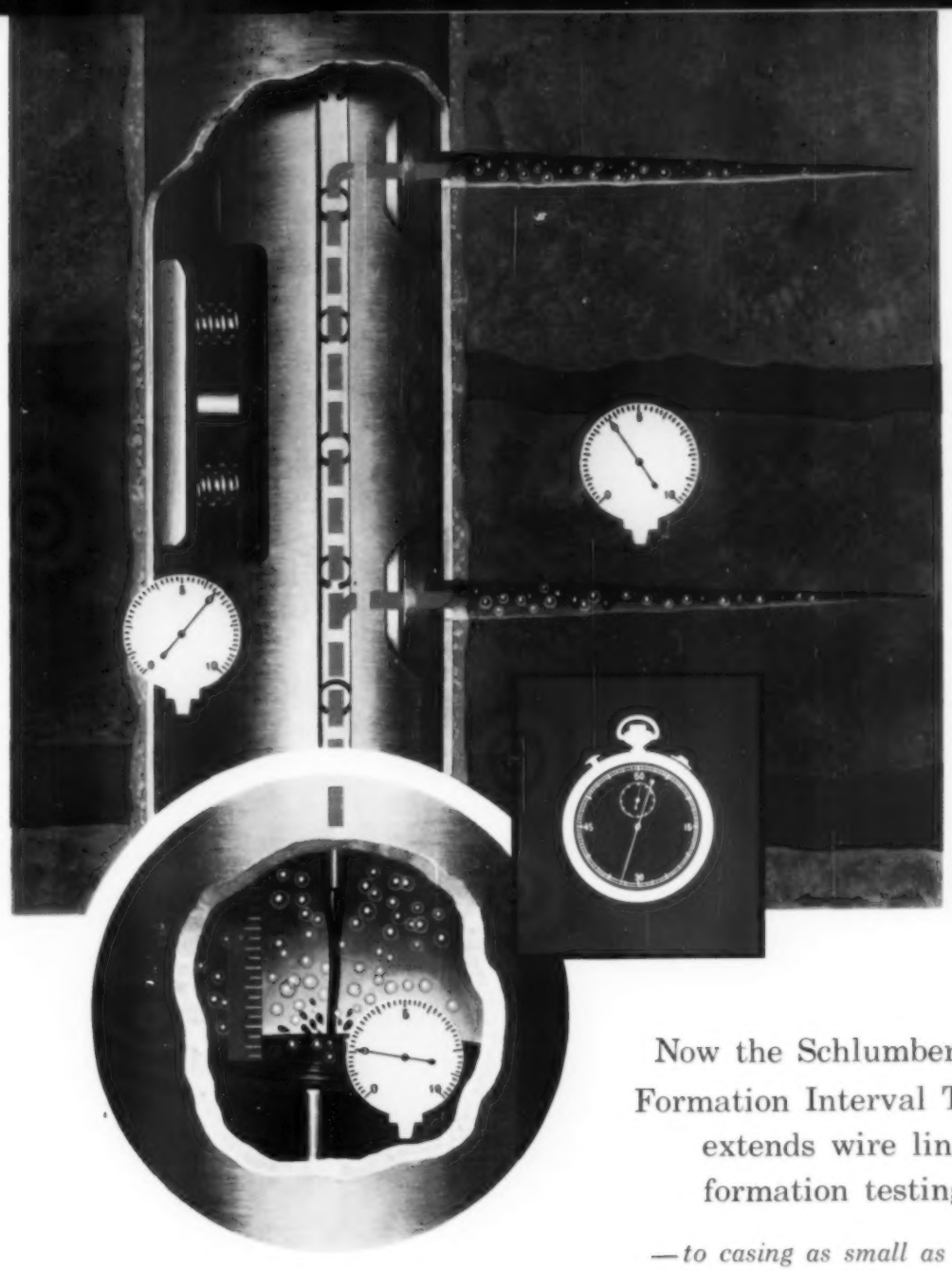

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RUNNING TOUR

Personnel assignments have been announced in Gulf Oil Corporation's Midland and Oklahoma production districts.

Midland district manager is **E. E. Merkt Jr.; H. B. Leeton** is production manager; **J. A. Hord** exploration manager, and **N. B. Martin,** manager of services. On the exploration staff are **J. A. Norwood,** district exploration geologist; **R. E. Griffith,** landman, and **C. E. Davis,** manager of the area exploration office.

Production functions will be handled by **J. L. Coulson,** assistant production manager; **T. W. Kidd,** district engineer, and district production geologist, **L. L. Fuller.** Area production managers are **A. J. Evans Jr.** at Crane; **C. H. Jones** at Goldsmith; **C. D. Borlands Jr.** at Sand Hills; **V. G. Davis** at Monahans; **C. M. Foster** at Wichita Falls, and **J. F. Eubanks** at Odessa.

Appointments in services department include **C. E. Fields,** district clerical supervisor; **W. T. Comfort,** purchasing and transportation supervisor; **C. F. Wilson** as general services supervisor, and **R. F. Welter,** district personnel and payroll supervisor.

Oklahoma City district manager is **E. L. Petree.** In charge of the district's various functions are **P. A. Weirich,** exploration manager; **A. C. Godbold,** production manager, and **Keith Smiley,** services manager.

In exploration are **R. W. Maxwell,** district exploration geologist; **W. B. Robinson,** district geophysicist, and **D. D. Adams,** district landman. Production has **W. C. Palmer,** district engineer, and **A. L. Latta,** district production geologist.

Area exploration managers are **R. L. Boss, C. R. Scurlock, K. W. Bumgarner,** and **M. L. Miles.** Area production managers are **E. A. Weichert, W. C. Best, W. H. Duley,** and **G. V. Kersten.**

Delhi-Taylor Oil Corporation announced the promotion of **Norman C. Miller,** chief geologist, to the newly-created position of manager of exploration. In this post, Miller will supervise all foreign and domestic exploration activities for the company. He will be succeeded as chief geologist by **J. D. Nunnally,** formerly exploration coordinator-Gulf Coast for Gulf Oil Corporation.

N. C. Miller

J. D. Nunnally

Charles B. Morgan has resigned as manager of exploration for Petroleum Exploration, Inc. of Texas to open geological consulting offices at Amarillo, Texas. Morgan will continue as consultant with PEI.

John Knudsen Jr. has been elected president of Kent Petroleum Corporation. He has more than 21 years of experience in the oil and gas industry, and holds membership in American Petroleum Institute and American Institute of Mechanical Engineers.

Another plus value:

Inherent Lubricating Qualities Broaden Use of Seeco-Mul As E-P Additive

Seeco-Mul Also Affords Faster Penetration, Extends Life of Bits, Collars, and Liners

On your next well, try Seeco-Mul Drilling Mud Additive as an extreme pressure additive. Many operators have recently discovered this extra advantage in Seeco-Mul; in fact we can show you data on a number of field wells drilled under almost identical conditions that will convince you that Seeco-Mul is the most effective E-P agent you can use.

The efficiency of Seeco-Mul as an E-P agent is due to its chemical structure — the ability of one end of the Seeco-Mul molecule to adhere tightly to a metal surface, attracting another molecule to form the familiar micelle, or the joining of two molecules at opposite ends. This layer attracts other Seeco-Mul molecules, which build up to an extremely tough lubricating film that is difficult to remove and will withstand high pressure, successfully reducing metal-to-metal contact and subsequent wear, or galling, of the bearing surfaces.[1]

In addition to the E-P qualities, you get many other advantages with Seeco-Mul. Inasmuch as Seeco-Mul is a chemical emulsifier with superior wetting abilities, it is often run in so-called "soap" drilling fluids (the addition of detergents to fresh water muds, oil-and-water, and water-clay systems) to lower the surface tension, thereby wetting the formation ahead of the bit and keeping the bit clean. Such systems also afford a faster penetration rate and aid the suspended solids to drop out in the pits.

Too, with good lubricating qualities in the mud, less drill stem torque is required, pump pressures can be lowered and more evenly sustained, and a higher velocity of the fluid on bottom can be obtained . . . all of which means longer service life for liners, collars, tool joints, drill pipe, and the bits themselves.

Add to this the longer bit runs and the consequent savings in bits and rig time and you will agree that adding Seeco-Mul to the system is an investment rather than a drilling expense.

Let us show you how you can use Seeco-Mul profitably. We'll gladly send you illustrated literature and a lab sample of Seeco-Mul, or contact your local mud dealer. You can get full particulars without obligation.

[1] *McCutcheon, John W., "Synthetic Detergents."*

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CROSSETT **Seeco-Mul** **DRILLING MUD ADDITIVE**

Manufactured by the Chemical Division of The Crossett Company, Crossett, Arkansas

Seeco-Mul is the dried flake form of a compound of the sodium salts of abietic, linoleic, and oleic acids, together with quantities of wood tannins and lignins.

▸ Phillips Petroleum Company has announced promotions in two divisions of its land and geological department.

S. J. Talley has been transferred from the company's Bartlesville, Oklahoma, headquarters to Midland, Texas, to assume the position of assistant division manager and division exploration geologist. **R. A. Wolgast,** formerly district landman at Durango, Colorado, has been moved to the Denver office as division landman.

▸ A number of personnel transfers were announced by Tennessee Gas and Oil Company, the domestic and Canadian oil and gas exploration and production division of Tennessee Gas Transmission Company.

J. A. Leask, district production superintendent, has been transferred to the Corpus Christi, Texas, district office from Edmonton, Alberta, Canada. He replaces **Frank H. Harrell,** who has resigned. The Edmonton and Calgary, Alberta, district production offices were consolidated into a single office in Calgary.

Vernon T. Bolleter, formerly district exploration superintendent at Bellaire, Texas, has been transferred to Durango, Colorado, exchanging places with **John H. Simons,** now assigned as district exploration superintendent at Bellaire.

D. C. Anderson, junior exploitation engineer, has been transferred from Casper, Wyoming, to Oklahoma City, Oklahoma.

▸ **John A. Cathey** has been appointed chief geophysicist for Lion Oil Company, headquartering in Houston.

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▸ **Sam F. Shakely,** Oklahoma City, has been named manager of production for Anderson-Prichard Oil Corporation. In the newly created position, Shakely will work directly with **Dr. R. W. Brauchli,** vice president of exploration and production.

S. F. Shakely

G. A. Burton

▸ **Gerald A. Burton** has been named exploration manager for Shell Oil Company's Pacific Coast area. Burton will replace **Leo F. Newfarmer,** who is being transferred to Houston.

▸ Several personnel changes have been announced within the exploration department of Kerr-McGee Oil Industries, Inc. **Robert B. Capps** has been named assistant chief geologist in charge of development operations in coastal and offshore areas. **Robert L. Duncan** has been transferred to New Orleans as division manager. **J. Robert Stevenson,** a district geologist in Canada, has been named manager in that area.

▸ **H. D. Spires** of Tidewater Oil Company has been named assistant district production manager in the San Joaquin Valley, California, for the Flying A firm. In his new post Spires will be headquartered at Oil Center near Bakersfield.

▸ Cities Service Oil Company has made several personnel assignments.

E. W. Dissler of Calgary, Canada, has been appointed manager of exploration. He succeeds **R. H. Tucker** in exploration managership following Tucker's recent election as vice president of the parent company.

C. E. Cole of Shreveport, Louisiana, is the new exploration manager of Canada-Cities Service Company at Calgary. **Barron Housel** of Bartlesville, Oklahoma, has been appointed superintendent of Cities Service's land department.

James W. McColl of Bartlesville, Oklahoma, has been selected to head a new group being formed for acquiring new properties, Cities Service has announced.

▸ Jocelyn-Varn Oil Company has opened a field office in Corpus Christi, Texas. New regional office in the Watson Building will be managed by **Meredith Jocelyn.**

▸ Three promotions to newly created posts in its production and supply department have been announced by Trunkline Gas Company of Houston.

Appointed to district managers of exploration were **Raymond E. Fairchild,** Houston district; **Robert H. Dickerson,** Corpus Christi district; and **Wallace K. Cox,** Lafayette district. Each assumes responsibility for all geological, land and geophysical activity in his respective district.

▸ **Ben A. Lovell** has peen appointed gas coordinator for Sunray Mid-Continent Oil Company's central division. He succeeds **H. H. Everett,** who resigned recently to accept a position with another firm.

James E. Finley, Fort Worth, Texas, has been appointed exploration manager for Continental Oil Company's Rocky Mountain region, with headquarters in Denver.

Joe H. Miller has been named manager of process and control engineering for Suntide Refining Company in Corpus Christi, Texas.

Robert O. Anderson, president of Hondo Oil & Gas Company of Roswell, N. M., has been elected a member of the board of directors of Northern Natural Gas Company.

Several organizational changes in the minerals division of Kerr-McGee Oil Industries, Inc., have been announced. **V. L. Mattson** has been named general manager, minerals; **R. T. Zitting** is now manager, mineral exploration and land. **Phil Ellsworth** has been promoted to chief geologist, minerals.

J. A. Murphy

John A. Murphy has been appointed executive vice president of Texam Oil Corporation. He will supervise all exploratory activity and other technical operations of Texam Oil and evaluate new prospects for the company's investment drilling program.

N. L. Falcon, chief geologist of British Petroleum Exploration Company since 1952, has been elected a fellow of the Royal Society. He served in Persia until 1936, has held geological posts in Scotland, and now has special responsibilities for United Kingdom exploration and photogeological operations.

Standard Oil Company of California, Western Operations, Inc., has announced establishment of a new land department and appointment of **D. G. Couvillon** as general manager. New department consolidates activities previously conducted by the company's real estate and right of way department, land division of the exploration department, and contracts division of the producing department.

Managers of divisions in the land department were **W. H. Savage,** land acquisition; **G. F. Schroeder,** contracts, and **D. B. McHenry,** real estate and right of way. All carried on these same functions separately under the previous organization.

William R. "Bill" Yinger, Oklahoma City petroleum engineer, has entered exploration and production as an independent operating in Oklahoma. He was formerly vice president and exploration manager for King-Stevenson Oil Company.

James LeBlanc has been promoted to Houston district landman by the Trunkline Gas Company.

George B. Baan has joined Handy Associates, Inc., as vice president of international operations with headquarters in New York. Baan directs overseas services for American and foreign companies, including market studies, organization planning, and surveys.

2

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When a conventional rod pump will no longer produce enough fluid to make the oil allowable, many operators save money by running a Harbison-Fischer Double-Displacement® Rod Pump instead of installing a tubing pump.

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The Double-Displacement is a traveling barrel, bottom hold-down assembly with two plungers and two barrel tubes which work simultaneously with a single set of valves. Pumps are available in a wide range of metal-to-metal, H-F Flexite®, or soft packing plungers, with chrome-plated or heat-treated barrel tubes in 2" x 1½", 2½" x 2", and 3" x 2½" sizes.

One installation will convince you that a Double-Displacement Rod Pump is the "Best Pump in the Oil Patch"® for large-volume production. You can obtain full details, illustrated literature, and comparative production data without obligation from your store, one of our many factory representatives, or by writing us at Box 2477, Fort Worth.

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EXPLORATION ACTIVITIES

ALASKA

Second Wildcat Staked On Kenai Peninsula

A 13,500-ft wildcat has been staked on the Kenai Peninsula in Alaska by Michel T. Halbouty. It is No. 1-B Alaska Oil & Mineral Company-King Oil, Inc., a joint venture. Halbouty's company, known as Halasko, will serve as operator.

Venture is the second test — the first was a dry hole — drilled by the concern on the peninsula. It is nine miles south of two large producing wells recently completed by Standard Oil Company of California and Richfield Oil Corporation.

AUSTRALIA

Partners Will Explore Island Off Queensland

Delhi-Taylor Oil Corporation, Dallas, has announced that its subsidiary, Delhi Australian Petroleum Ltd., will start work in August on a new exploration in Australia.

Delhi Australian will be joined by Santos Ltd., an Australian concern, in the venture, which will be located on Mornington Island in the Gulf of Carpentria, Queensland.

Projected depth of the hole is 6000 ft. Geologically, the test is described as being in the Carpentria Basin which is an extension of the Great Artesian Basin where Delhi Australian and its partners have drilled two unsuccessful test operations.

CALIFORNIA

Wildcat Well Flows 1200 BPD in Los Angeles

Discovery of a new oil field in the La Brea-Crenshaw district of Los Angeles was reported jointly by Union Oil Company of California and Signal Oil and Gas Company.

Officials of the two companies said they feel "this new field discovery could prove of major importance." Union, operator of the drilling venture, has a 60-percent interest and Signal a 40-percent interest.

On preliminary tests the wildcat well, Union-Signal PE 3, flowed 37 gravity crude oil at the rate of 1200 bbl per day through a 26/64-in. choke. Discovery well is located near the intersection of Pico Boulevard and La Brea Avenue.

Two additional wells which electric logs indicate will also prove productive are awaiting preliminary tests.

Union and Signal have leases on about 7000 acres surrounding the discovery. These leases were signed with nearly 25,000 homeowners in the area before exploratory drilling was started.

Discovery well will be shut in awaiting installation of production facilities. The drilling rig will be skidded to a location for a fourth well, which will be started in a few days.

CANADA

Successful Gas Discovery Flows From Killam Sand

In Canada, Drilling and Exploration Company has indications of a successful discovery well in the Province of Alberta. The Killam Number 11-3 was drilled to a total depth of 3150 ft. On a drillstem test from 2755 to 2855 ft the well flowed at the rate of 350 Mcf of gas per day from the Killam Sand.

Below, in the Basil Quartz sand from 3004 to 3018 ft, the well flowed at the rate of 4500 Mcf of gas per day. It has been shut in prior to the establishment of a market for the product.

GREECE

Helios Receives Grant To Prospect in Thrace

The Greek firm Helios, S. A., has been granted a concession to prospect for oil in Thrace, Northern Greece. The French state-controlled agency Regie Autonome des Petroles (RAP) will guide and supervise oil prospecting for Helios. Two cooperating companies are required to carry out by April, 1961, drillings of a total depth of 3000 meters and to spend $500,000 annually in oil exploration work to be completed by April 1964.

IRAQ

Government Invites Bidding On 100 Wells in Desert

Iraq's Directorate General of Rural Services, Ministry of Municipalities, invites bids until August 31 for drilling and completing 100 wells in the northern and southern deserts with all equipment and constructional work.

Project is to be carried out according to contract documents and drawings which may be obtained from the accountant, directorate general of rural services, Baghdad.

Project is sanctioned in the Interim Economic Plan, for which a sum of $1,960,000 has been allocated for expenditure during 1960 to 1962.

LIBYA

Third Largest Oil Well Flows 11,500 BPD in Dahra Field

Completion of an oil well in the Dahra field of Libya, which flow-tested at the rate of 11,500 bbl per day has been reported by Amerada Petroleum Corporation, Continental Oil Company, and the Ohio Oil Company.

Located in Concession 32, the F-9 well is the largest yet brought in by the group. It is the third largest ever completed in Libya.

Well, flowing 40-deg gravity crude, extends the Dahra field two and one-quarter miles southeast from the group's F-2 well which has tested at the rate of 8000 bbl per day. Crude from the new well flowed through perforations from 3066 to 3106 ft and 3120 to 3130 ft.

Well's total depth is 3374 ft.

F-9 well is the group's 11th oil or gas producer in the Dahra field.

MONTANA

Deep Natural Gas Test Set in Glacier County

A deep test for natural gas will be started before July 1 in the Two Medicine Creek area of Glacier County, about 41 miles west of the Cut Bank oil and gas fields.

The Montana Power Company has an arrangement with Union Oil Company of California for the utility to underwrite a well on land held by Union in return for an interest in the leases. Great Northern Drilling Company will be the contractor and will drill the well under an agreement with Montana Power.

Efforts to unitize the field are proceeding. The U. S. Geological Survey has given preliminary approval of unitization of the federal lands involved. Test scheduled, as tentatively planned, will be drilled into the Madison formation to a depth of about 9200 ft. Land is on the Blackfeet Indian Reservation in an area where Union has extensive leases.

PORTUGUESE GUINEA

First Exploration Program Scheduled For Fall

Esso Exploration Guine' Inc., a subsidiary of Standard Oil of New Jersey, has awarded a drilling contract to Drilling and Exploration Company for several exploration wells in Portuguese Guinea, West Africa.

Equipment for the drilling program, including the rig, will be shipped from Malta and is scheduled to arrive at the port of Bissau on Africa's West Coast about October 1st. Drilco will provide supervision and technical assistance for drilling the wells.

Free sets of full-color reproductions of core samples, suitable for office decoration, are available. Request must be made on your company letterhead, and include name of this magazine and date of issue. Address — Core Lab, Box 10241, Dallas 7, Texas.

Underneath West Texas

Strawn Lime, Huildale Field, Schleicher County, Texas: producing depth 6238 feet; productive thickness, 46.1 feet; permeability, 99.9 millidarcys; porosity, 7.9%; residual oil, 12.0%; total water, 38.4%.

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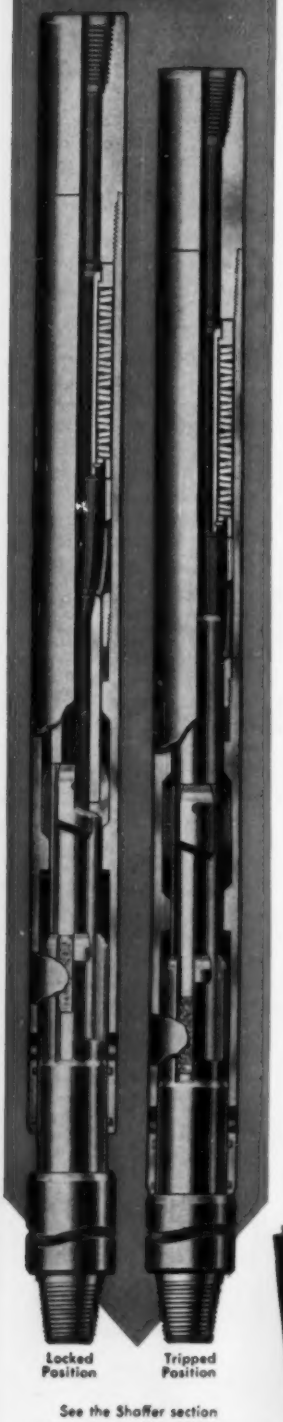
For running in the drill string . . .

Positive JAR-DOWN ACTION

. . . plus Safety Joint protection!



See the Shaffer section of your Composite Catalog.

THE SHAFFER-WAGGENER BUMPER SAFETY JOINT

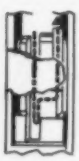
There is no other tool like the Shaffer-Waggener Bumper Safety Joint. It combines—in ONE tool—a choice of *jar-down* and *releasing* actions, both under complete control of the operator. What's more, the tool is so rugged it is run as part of the drill string to protect against stuck pipe.

In actual well service it has operated easily at depths below 18,000 feet, and has given no operating problems even in directionally-drilled wells with extreme slant.

Jar-Down Action

▶ **RUN IT IN THE DRILL STRING**—It is specifically designed to withstand the continuous vibration and heavy torque loads of today's drilling operations.

▶ **TO JAR DOWN** whenever the drill pipe threatens to stick—or to drive drill collars out of keyseats and to free "balled-up" bits—simply slack off weight equivalent to about 2,000 feet of drill pipe onto the tool. This releases the tripping mechanism, automatically striking a sharp down blow. Raising the string automatically re-sets the tool for another blow—and blows can be struck repeatedly as fast as the string can be raised and lowered. And no torque or twisting strains are placed in string!



Releasing Action

▶ **TO RELEASE,** in the event jarring will not loosen the stuck string, simply trip the tool and apply reverse torque as the string is slowly raised. Only one-sixth turn of the tool rotates the drive keys into unlocking slots so that complete release is effected by continuing to raise the string.

ANOTHER ADVANTAGE—the tool transmits full torque loads in *either* direction through three rugged drive keys—not through easily-damaged threads. It is the strongest joint in the string—not the weakest, as with conventional safety joints.

Also, the tool can be re-connected again by simply lowering the top portion over the lower portion and reversing the releasing action. It is ideal for use in fishing strings!

SWITZERLAND

First Deep Test Well Spudded in Fribourg

British Petroleum Exploration S. A. Fribourg has spudded in its first exploration deep test well in the Canton of Fribourg, Switzerland. Well is being drilled by BP under contract with Societe d'Interets Miniers S. A., and will be known as Courtion No. 1. The site is about 10 kilometers northwest of the City of Fribourg near the village of Courtion.

It is anticipated that a second test well will also be drilled by BP.

TEXAS

DeWitt County Wildcat Flows 1689 MMCFD

Lion Oil Company Division of Monsanto Chemical Company has completed a wildcat well southeast of Yorktown in DeWitt County, Texas.

Walter Feller No. 1 was drilled to a total depth of 10,715 ft and completed as a gas-condensate discovery from perforations between 9524 and 9538 ft in the Lower Wilcox.

Well flowed 1,689,000 cu ft of gas and 70 bbl of condensate per day through 10/64-in. choke. There were other potentially productive zones at lesser depths which were not tested.

Discovery was drilled on a block of about 1600 acres jointly owned by Monsanto, H. P. Darcy, and Continental Oil Company.

Discovery Well Completed In Scurry County

A discovery well has been completed in the Southeast Fluvanna area of Western Scurry County, Texas. Jones Brothers A-1 has been completed in the Strawn section. Total depth of the well was 8291 ft, where 5½-in. casing was set.

Well was perforated from 8153 to 8158 ft in the Mississippian section, and swabbed at the rate of 8 bbl of fluid per hour — 50 percent oil and 50 percent water. Bridge plug was set and completion was made in the Strawn section through perforations opposite the interval 7810 to 7820 ft.

On potential test the well pumped 165 bbl of oil and 145 bbl of water in 24 hours. Drilexco controls 3379 acres in the area. Additional drilling is now in progress.

Morrow Pennsylvanian Gas Producer Confirmed

James F. Smith, et al, has confirmed a Morrow Pennsylvanian gas producer in the Panhandle. The 1 Conden in Ochiltree County was brought in for 1800 Mcf per day from 7612 to 7620 ft.

This is a northeast offset discovery

to the pool opener which made 6100 Mcf per day. Location of the well is Section 93, Block 11, W. Ahrenbeck Survey, which is six miles northwest of Perryton in the northwestern part of the county.

Drillstem Test Shows Oil From Strawn Pennsylvanian

Southern Tom Green County wildcat in West Texas, 6 miles south of Knickerbocker, found oil on a drillstem test of Strawn Pennsylvanian at 6857 to 6952 ft. It is British-American Oil Producing Company 1 S. N. Allen, located five miles south of Atkinson field in Section 16, Block 21, H&TC Survey.

Recovery was 5300 ft of 41 deg gravity oil and 100 ft of oil-cut mud. Another test is being made at 6952 to 6977 ft.

Multiple Pool Discovered In Red Deer Creek Field

A multiple new pool gas-condensate discovery in the Red Deer Creek field in Roberts County, Texas, has been brought in by Gulf Oil Corporation.

New discovery well, Osborne No. 2 in Section 26, Block B-1, H&GN Survey is dually completed from perforated intervals of granite wash at 9570 to 9590 ft and basal Pennsylvanian conglomerate at 10,840 to 10,890 ft. In initial production tests of the lower zone perforations, flow was at the rate of 4,400,000 cfd through a 22/64 in. choke. Fifty-two barrels of condensate were recovered per million cubic feet of gas.

Well is completed at a total depth of 11,567 ft in Mississippian lime. Seven inch casing is set at 10,600 ft and 5½ in. liner at 10,474 to 11,535 ft. Two strings of tubing are set on packers to separate the two producing zones. Gulf has about 9000 acres under lease in the area.

NEW SOUTH WALES

Two Companies Will Explore Area in New South Wales

Three areas totaling 12.300 sq miles in the Hunter River Valley of New South Wales will be explored by Union Oil Company of California and Kern County Land Company, participating with the Australian Oil & Gas Corporation.

Areas are in addition to the 60,000 sq miles in which the three companies are presently exploring in southwestern Queensland and northern New South Wales.

Under terms of the arrangement, Union Development Company, a wholly owned subsidiary of Union Oil Company, and Kern County Land Company are jointly financing the program.

For fishing, testing and core-drilling strings . . .

. . . plus Safety Joint protection!

Positive JAR-UP ACTION

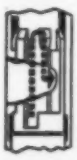
THE SHAFFER OIL-SEALED JAR SAFETY JOINT

The Shaffer Oil-Sealed Jar Safety Joint is the only tool that combines a choice of *jar-up* and *releasing* actions, both under complete control of the operator at all times. What's more, all operating parts are sealed in a chamber filled in clean oil, fully protected against mud, sand and corrosive fluids.

The sealed-in-oil protection not only safeguards against abrasion and corrosion, and minimizes pressure differentials on packing elements, but also insures constant operating characteristics at all depths. This makes the tool ideal for fishing, testing and similar strings where light connections and equipment are used!

Jar-Up Action

JARRING ACTION IS AUTOMATIC—simply raise the drill string until tension equals the pre-set tripping load, whereupon a sharp up blow is struck. Lowering the tool automatically re-sets the tripping mechanism for another blow—and repeated blows can be struck as fast as the string can be raised and lowered.



Releasing Action

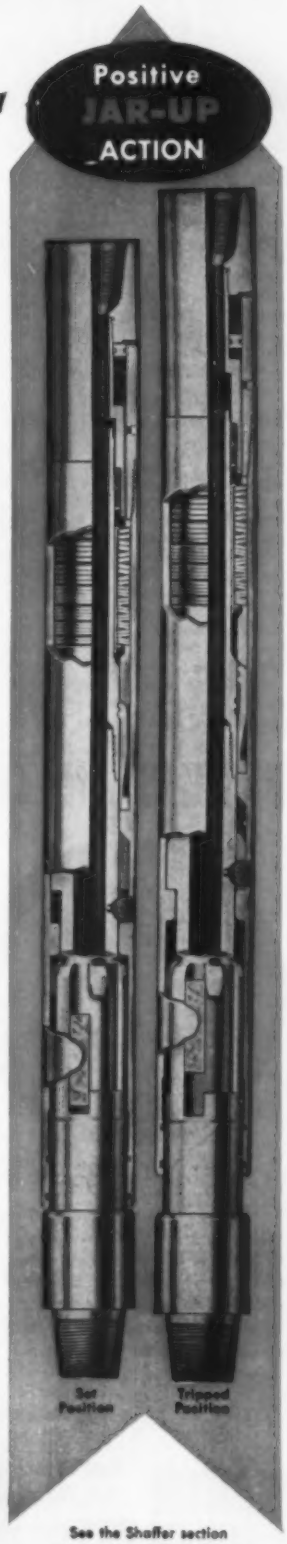
ONLY STRAIGHT PULL is necessary to operate the tool—no torque or other secondary operations to affect the light connections commonly used in fishing, testing and coring strings.

TO RELEASE, in the event the fish or stuck string cannot be loosened, simply trip the tool and apply reverse torque as the string is slowly lowered. Only one-sixth turn of the drive keys rotates them into an unlocking slot whereupon raising the string allows the parts to unlock.

AND NOTE THIS—not only does the tool transmit full torque loads in *either* direction, but no threads are used in the releasing mechanism. Therefore there's no risk of torque over-tightening the tool—nor can reverse rotation accidentally release it.

Also, force of the blow is absorbed by integral knocker heads—not by easily damaged drive keys or threads. The tool is designed for *sustained* jarring operations. And since it does not depend upon friction for its tripping action, the Jar Safety Joint always operates with the same pre-set action. Light strings are not subjected to unpredictable loads!

Free 8 page booklet gives many other facts about the Shaffer Oil-Sealed Jar Safety Joint. Write for it—or ask your nearest Shaffer representative.



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Drilling – Producing Equipment

Formation Tester Modified For 5½-in. Casing

Schlumberger Formation Tester has been modified through the addition of a second shaped charge and a redesign which permits testing inside 5½-in. casing. Second perforation allows testing of an 8-in. interval rather than a single point, thus reducing the chance of testing an impermeable stringer. *Schlumberger Well Surveying Corporation.*

Circle number (1) on reply card.

Gate Valve

Saf-T-Seal gate valve provides a tight seal both up and downstream, and requires no lubrication. Valve is available in the ASA 400 and 600 lb class, and it is being introduced in the larger sizes ranging from 14 to 42 in.

Unusual feature of valve is design of floating seats. They are similar to those of the pressure sealing gate valve, since each seat consists of two kinds of elastomer bonded to a metal seat insert. Soft elastomer for sealing is molded into the back of the heavy ductile iron seat insert.

Seats also provide a double action seal. Tough elastomer creates a primary seal against the gate, and as line pressure is increased, the gate compresses the elastomer ring until the gate rests against the metal seat.

Body and bonnet are cast steel and stem is heat treated, hardened, chrome-plated steel. Gate is made of steel, hard chrome-plated for protection against wear and corrosion. *W-K-M Division of ACF Industries, Inc.*

Circle number (2) on reply card.

Digital Computer

Packard Bell has announced an ultra-fast, general purpose, digital computer. Designated PB250, the specifications qualify the computer for either on or off-line applications. It serves as an engineer's desk-side computer, and has an on-line computer for process monitoring, process control, data-logging, and alarm generation.

Computer combines a large, expandable memory and a versatile command structure with computing speed in the microsecond range. It is a serial, binary, single-address computer with an internally stored program. A few features include microsecond speed . . . add/subtract —12 usec, multiply—276 usec, divide/square root—252 usec. *Packard Bell Computer Corporation.*

Circle number (3) on reply card.

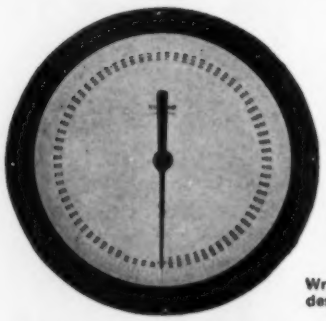
Variable-Speed Sheaves

Two additional sizes of variable-speed sheaves, 10 hp at 1750 rpm, and 15 hp at 1750 rpm, have been added to the Wood line. Both have maximum-pitch diameters of 10 in.

Horsepower ratings are based at constant torque and for maximum speed, that is at maximum pitch diameter. Variable-speed pulleys are designed to eliminate fretting, corrosion, freezing and sticking. *T. B. Wood's Sons Company.*

Circle number (4) on reply card.

PRECISION TEST GAUGES



Designed for the Ultimate in Accurate Pressure Measurement

Write for descriptive brochure M-28A

Consider These Advantages:

- 360° Calibration provides 25% greater scale length.
- Saves over 115 square inches of panel space.
- Ni-Span C Bourdon tube is temperature stable.
- Tube tip bleed is standard equipment.
- .15% full scale accuracy.
- Movement calibrated to dial, uniform increments.
- Capacities to 15,000 psi.

Write For Descriptive Bulletin E-31

MARTIN DECKER

Martin-Decker Corporation
3431 Cherry Ave., Long Beach 7, Calif.

Precision Pressure Instruments— Testing — Weighing — Load and Force Measurement

Casing Pump Designed For High Volume Wells

Casing pump which features both anchor and seal at the top has been introduced by Continental-Emsco. Fluid column is held above the seal to stop sand and foreign material from sticking pump and packer. Because of top hold-down, bbl tube does not operate in compression and it remains free of distortion.

New product is a special application type pump designed for high volume wells where increased plunger displacement is necessary to obtain desired production.

Pump has a mechanical by-pass valve that is open while going in or coming out of the hole, which reduces load on sucker rod string when pump is unseated and minimizes pressure so that packer is easier to pull.

Three large dove-tailed slips, operating on a flat surface, support fluid weight in casing. This means that load is distributed uniformly over entire slip area, eliminating casing deformation and making packer easier to pull. Slips are securely held in position, minimizing possibility of hanging in casing collars when running or being pulled.

Sizes available are 2¼ through 3¾ in. for use in casing sizes of 4½, 5, 5½, 7, and 8⅝ in. O.D. *Continental-Emsco Company.*

Circle number (5) on reply card.

Fluid Loss Agent

Multi-purpose fluid loss agent introduced by Halliburton is designed for extended fractures and deeper sand penetration. Fluid retention properties approximate 20 to 25 ml in 30 minutes.

Agent was developed to fracture highly permeable formations, since for most formations it can block the fracture face temporarily and make it possible to treat with less pressure and reduced pumping horsepower requirements.

Agent may be used with either batch or continuous mixing operations in strong or weak acid solutions, fresh or brine water, and it is compatible with most surfactants used in water or acid-base fluids. *Halliburton Oil Well Cementing Company.*

Circle number (6) on reply card.

Hole Enlarging

You can get from Grant!

This is just one of the three *families* of Grant Tools made for reaming, hole enlarging and stabilizing. For full information on these, and a wide range of other down-hole and surface tools made by Grant, send for your copy of the complete Grant Catalog today, or see the Grant section of Composite Catalog!

Every hole enlarging job presents its own special set of conditions. That is why Grant, with more experience in this highly specialized field than any other manufacturer, has engineered specific tools for *your* particular job. For opening rat-holes . . . enlarging hole for the casing string . . . under-reaming before cementing—in any well—Grant's 30 years of specialization have produced the right tool for the job at hand.

When hole enlarging is your requirement, *remember that only Grant makes and services all types of hole enlargers in active oil territory everywhere!*

GRANT OIL TOOL COMPANY

2042 EAST VERNON AVENUE, LOS ANGELES 58, CALIFORNIA
Cable Address: GRANTOOL

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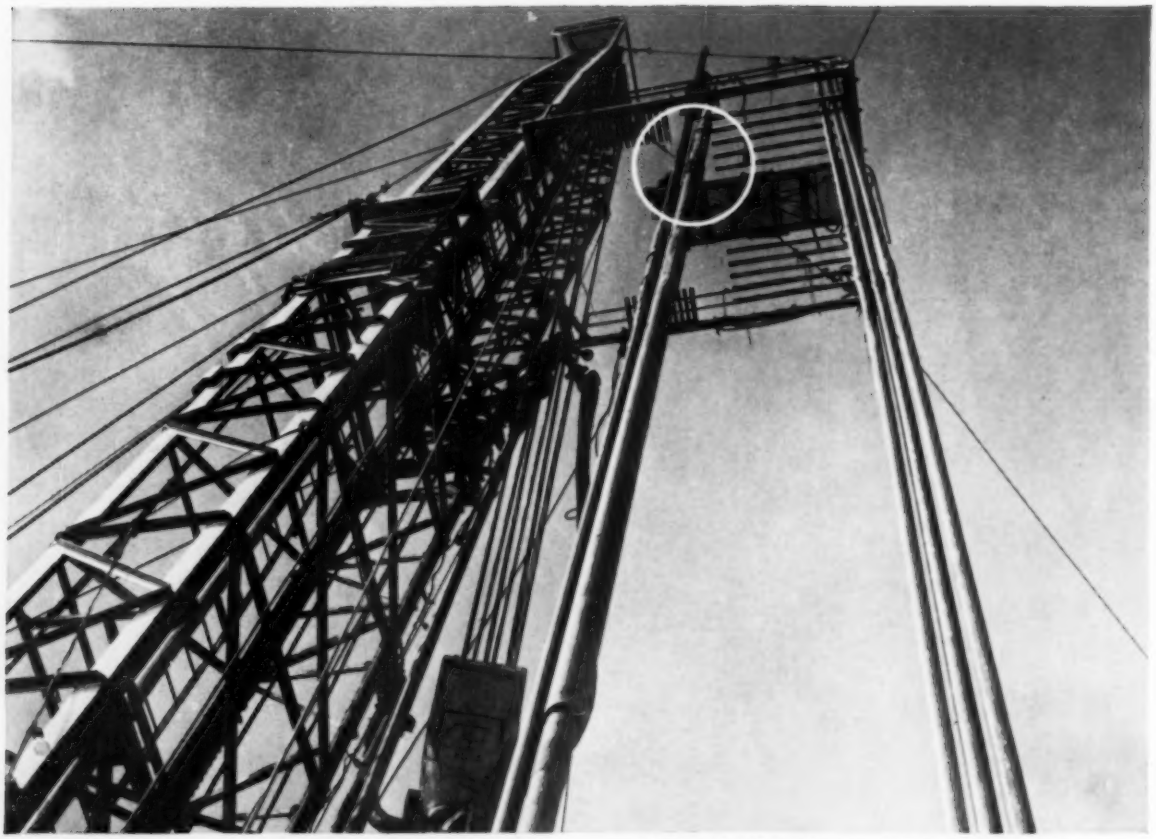


Work-over rig in field near Houston, Texas, with Wilson pulling tool in place to pull old liner. Type 4340 nickel alloy steel insures long trouble-free life for piston head and rod assembly in this 40-foot-long tool. Note anchor section at top. Hold down slips (three visible) are hard-wearing AISI 4620 nickel alloy steel.

Going fishing?

4340 and 4620 nickel alloy steels provide safe 300-ton pulling power

With no strain on the rig or string, this pulling tool can yank old liners, packers and other objects out of the hole in jig time.

Its action is hydraulic; first, to set an anchor section; second, to actuate a 5-stage "jack" section that exerts a 300-ton pull on the fish over a distance of two feet. Then if another yank is needed, the puller can be reset.

Pulling tool protects rig; nickel alloy steel protects puller

Since the pulling tool and not the rig takes the whole brunt of the pull, its integral piston head and rod assembly must be extremely strong and resistant to hard wear and impact. What's more, they must be finish machined *after* hardening. Altogether, a difficult combination of properties to achieve, especially in the sections used!

To meet these requirements, Wilson Supply Company uses AISI 4340 nickel-chromium-molybdenum steel. With this steel, strength, hardness and impact resistance are obtained even in large sections that compare favorably with those secured in small sizes with other steels. Furthermore, machinability is good at hardnesses of 360 BHN and higher.

Outstanding performance can be expected from steels with Nickel in them and there is a wide range of such steels available, each with proven application in oilfield equipment. How and where can *you* benefit? If you are experimenting with some new device, or if you run into premature metal failure, call on Inco for metal data.

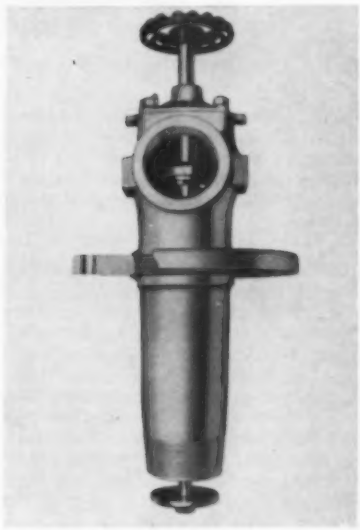
THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

NICKEL MAKES STEEL PERFORM BETTER LONGER

Water Draw-Off Valve

Water draw-off valve has two seats or valves mounted on the same stem. Inner valve seats first, permitting the chamber between the two seats to drain before outer seats closes. Inner seat is located well inside the tank, insulated by the chamber and surrounded by tank products to avoid freezing.



Unique feature allows operator to push on handle when inner seat is closed and outer seat is open, flushing foreign particles that might cause leakage off seat of inner valve.

Cap on end of valve body and outer valve can be removed and seat on outer valve replaced while inner seat remains closed against tank products, permitting valve to be serviced without expense and inconvenience of emptying tank.

Valve is furnished in 4 sizes for threaded or flanged tank mounting. *The Johnston & Jennings Company.*

Circle number (7) on reply card.

Matched V-Belts

Skinner Crown V-Belts, a new and complete line of matched V-belts designed to meet oil industry needs, has been introduced. Belts will be marketed through all major and independent supply stores in U.S. and Canada.

Three independent matching operations will be performed on all Skinner Crown V-Belts between factory and consumer.

Introduction of new line marks a further step in an expansion program undertaken recently by the firm. They have been field tested in both mud pump and production pumping application. *Skinner Brothers Company.*

Circle number (8) on reply card.

Dual Spaced Acoustilog

Lane-Wells dual spaced acoustilog is designed primarily for evaluating porosity in massive sandstones and carbonate formations. It offers the feature of recording both 1-ft and 3-ft spacing curves simultaneously with either a self potential or a gamma ray curve. Spacing refers to the distance between receivers on the instrument.

One-foot spacing gives a considerable amount of detail, which permits direct comparison with the Lane-Wells Minifocusedlog, the Minilog, the Focused Log and drilling time and core data. Three-foot spacing is used for averaging values over larger sections, and it is readily correlated with the Lane-Wells Induction Log, Electrolog, and other types of resistivity logs.

Self potential or gamma ray curve, made on the same run, provides positive reference with other types of logs.

Operating principle of the tool involves generation of a sharp, high-intensity sound. Sound passes through the formation and is picked up by sensitive detectors carried in the tool. Measurement is made of the time interval between the arrival of each pulse at the nearest and the more remote detectors. Interval time, a measure of the time required for sound to travel the fixed distance between the receivers through the formation, is recorded on the log. *Lane-Wells Company.*

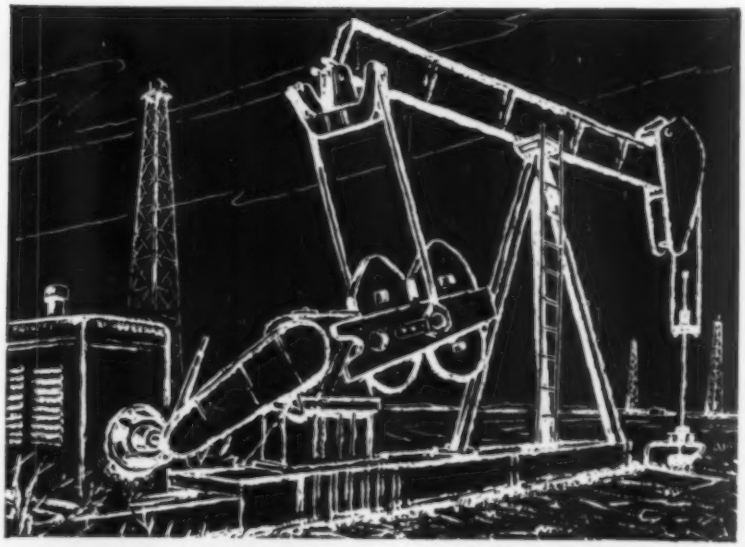
Circle number (9) on reply card.

Weight Indicator

Anchor type weight indicator for the small drilling rig and workover or production hoists has been introduced by Martin-Decker Corporation. Type "G" Weight Indicator provides all the service of the Type D, E, and FS used on the larger rigs, but the Type G is scaled down to be light in weight for stringent requirements of portable rigs.

Type "G" Deadline Anchor is side mounted to the derrick leg or other structure, and it provides a permanent mounting for the Sensater pressure signalling device. This unit is essentially uneffected by temperature changes and sends a lineal signal to the indicating gage mounted in front of the operator. *Martin-Decker Corporation.*

Circle number (10) on reply card.



PUMPING POWER
means production power!

Production power means time and money saved. Rockford Power Take-Offs are the perfect, controlled power-link between engine and work. These PTO's are used on many oil field rigs, independent power units, and built-in-engines. Next time specify Rockford. Many sizes and types of PTO's and clutches are available. Write today for complete details.

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You save drilling dollars with

THE

MUD PROBLEM: Control flow and filtration properties of mud in 3¾" hole at 20,000' depth, with temperatures of over 450 F.

WELL DATA

Location: Nicholson Field, Webb County, Texas
Total Depth: 20,603'
Bottom Hole Temperature: 456 F

MUD ADDITIVE PROGRAM

0' to 6,467'	AQUAGEL*, Q-BROXIN**, caustic soda, quebracho, water.
6,467' to 12,000'	Gypsum, Q-BROXIN, oil, BAROID*.
12,000' to 14,790'	DMS†-gypsum, Q-BROXIN, oil, BAROID, MICATEX*.
14,790' to 20,603'	CARBONOX* and DMS for control of flow properties and filtration, and BAROID for weight.

TYPICAL MUD PROPERTIES

Depth, feet	8,090	12,170	14,085	16,838	18,568	20,420
Weight, ppg	11.9	15.5	17.0	16.9	17.0	13.0
Viscosity, sec. API	51	59	61	46	45	48
Plastic viscosity, cp	31	46	55	30	27	22
Yield point, lb/100 sq ft	10	15	6	11	15	26
Filtrate, ml, API	6.0	3.1	2.1	1.5	2.2	2.2
Calcium, ppm	1000	1760	1360	200	400	200
Filtrate, cc API	7.0	10.8	86.0	12.00	11.2	11.0
tested at	225 F	325 F	375 F	375 F	400 F	400 F

CASING PROGRAM

Size Inches O.D.	*Depth Set Feet*
20	300
13⅜	6,474
9⅝	10,333
7 (liner)	10,126-14,971
4½ (liner)	14,619-18,563

*Registered Trademark, National Lead Company
**Registered Trademark, Puget Sound Pulp and Timber Company
†Registered Trademark, Magnolia Petroleum Company

DISCUSSION: Baroid's experience data indicated probable high temperatures, rock salt and lost circulation in this area. These conditions, combined with small hole drilling at lower depths and the need for mud that would not interfere with logging, made it necessary to control changing mud properties at each stage of drilling.

SOLUTION: An advance mud program was planned. Continuous laboratory, aging, high temperature and filtration tests were conducted. At 6,467' the treated shale mud was converted to a gypsum—Q-BROXIN mud in the casing. Below 12,000' mud was treated with DMS to control filtration and flow properties. Below 14,790' a CARBONOX—DMS mud was used to give trouble-free mud properties to total depth. Changes in mud properties were made without discarding existing mud and without loss of rig time. Mud did not interfere with logging or testing operations. Under changing conditions, extreme temperatures and small diameter hole, the viscosity, yield point, gel strength and other mud properties were maintained as desired at all times.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

a Baroid Mud Program

MUD PROBLEM

... and its solution

High temperatures and small diameter holes in deep drilling formerly presented serious drilling mud problems. Today, Baroid engineers plan successful mud programs that meet downhole conditions ahead of time and permit drilling to total depth without difficulty.

In this typical case, total depth was 20,603′. The last 1400′ of hole were drilled with a 3¾″ diamond bit. Bottom hole temperature was 456 F.

An advance program and constant pilot testing indicated every needed change in the mud. In the final stage, a CARBONOX—DMS surfactant emulsion kept mud properties under control as easily as in surface drilling. Logging and testing were done smoothly and successfully.

Baroid has reduced the element of chance and has increased the element of success in your drilling mud program by integrating every step of research, production, distribution and application into a single chain of service. This unified operation keeps your rigs on schedule and *saves your drilling dollars.*

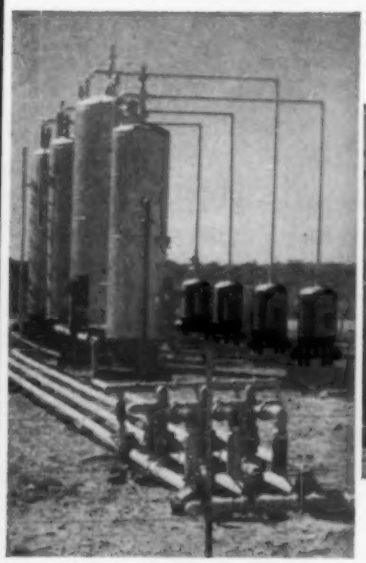
BAROID

BAROID DIVISION NATIONAL LEAD COMPANY

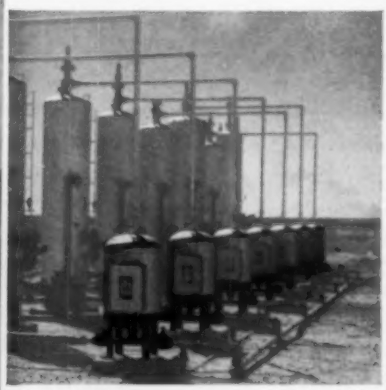
MAIN OFFICE: P. O. BOX 1675, HOUSTON 1, TEXAS

6044

METROL®
"CV" VOL-U-METERS®



METROL Model 10-CV-01 Vol-U-Meters metering and commingling oil from four separate royalty interests into a common tank battery.



METROL 10-CV-01 Vol-U-Meters metering and commingling oil from seven dual completed wells into a common tank battery.

METROL® "CV" VOL-U-METERS® are designed for accurate metering of crude oil and water by cyclic accumulation, isolation and discharge of equal volumes.

METROL "CV" VOL-U-METERS are available in standard sizes, ¼, ½, 1, 2, 5, 10, 20 and 30 barrels per dump. Standard working pressures are 125, 300, 600 and 1200 psi. Capacities are shown in table below.

Metering accuracy of METROL "CV" VOL-U-METERS depends on proper liquid level control and proper valving, both of which are obtained and maintained. Accuracies of 99.99% are common. This accuracy is attributed to the vessel's patented snap-acting pilot mechanism.* Pilots used on VOL-U-METERS are reliably accurate and react at exact preset upper and lower levels. VOL-U-METERS are approved by most regulatory bodies for measuring oil for royalty and tax payments, testing wells, and commingling oil.

Average repair parts cost for METROL "CV" VOL-U-METERS is less than $5.00 per unit per year! Ruggedness and simplicity of these units, added to their high accuracy and dependability, make them the best meter for metering crude oil upstream of lease storage tanks.

Accurate metered volumes, low maintenance cost, trouble-free operation, efficient and accurate handling of production, increased field safety, and additional lease automation are among advantages provided by METROL "CV" VOL-U-METERS.

UNIT MODEL NO.	2½ CV	5 CV	10 CV	20 CV	50 CV	100 CV	200 CV	300 CV
Volume per dump, Bbl	¼	½	1.0	2.0	5.0	10.0	20.0	30.0
Metering Capacity								
BPD Rated	300	500	720	1,440	2,000	4,000	8,000	15,000
Maximum	500	650	1,200	1,800	3,000	5,000	12,000	20,000
Avg. Expected Metering Accuracy, Percent	99.80	99.90	99.95	99.97	99.98	99.99	99.99	99.99

Every Unit is completely assembled, pressure tested, calibrated, and performance tested before shipment.

Competent Sales and Service Representatives located in all major oil areas.

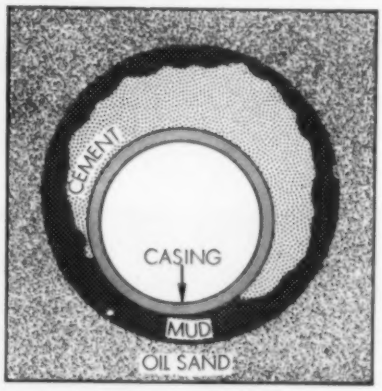
*Pat. No. 2,818,738

OIL METERING and Processing EQUIPMENT CORP.
MELROSE 5-1226 • 4843 YALE STREET
HOUSTON 18, TEXAS

B and W Inc.
SCRATCHERS AND CENTRALIZERS
for a good cement job

CHANNELING
is defined as . . .

CHAN'NEL.ING 1. To form a channel in; to groove. 2. To convey into or through a channel or channels. 3. **Oil Well Drilling.** In well cementing, a condition resulting from incomplete removal of fluid, gelled mud and filter cake from behind the casing by the ascending cement slurry.



CHANNELING MEANS . . .

(1) An imperfect primary cement job

(2) Mud left behind the casing

(3) Expensive squeezing

(4) A poor completion

B and W

SCRATCHERS AND CENTRALIZERS

Your best and most economical insurance for the elimination of channeling and a good primary cement job.

B and W Inc.
Well Completion Specialists

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WEST COAST
19706 South Normandie Ave.
Torrance, California
PHONE FAculty 1-2463

146

New Literature

Acidizing Services

A four-page, two-color Dowell bulletin describes "Acidizing Services for the Oil Industry." Included in the bulletin are descriptions and photographs of inhibitors, X acid, mud acid, breakdown acid, silicate control acid, retarded acid, intensified acid, channeling acid, stabilized acid, low surface tension acid, demulsifying acid, and special acid. Services described are abrasijet, jet gun acidizing, selective acidizing, fixafrac, temporary plugs, and other acidizing techniques. *Dowell Division of Dow Chemical Company.*

Circle number (11) on reply card.

Power Transmission

General engineering catalog of 468 pages describes all products in Dodge line of mechanical power transmission equipment. Comprehensive book is being presented on a selective basis to key personnel of industrial concerns, mainly through authorized Dodge distributors. Various sections are devoted to both new and established product categories, with engineering drawings, dimensions, weights, prices, technical data in tabular form; and selection and application information. Separate section on general engineering data make book a hand reference manual on mechanical power transmission. *Dodge Manufacturing Corporation.*

Circle number (12) on reply card.

Tools Described

The 1960 catalog has been issued by McCullough Tool, and this edition contains a complete description of their entire line of specialized tools and services. Catalog gives a comprehensive explanation of sizes, application and operation of all company tools and services. *McCullough Tool Company.*

Circle number (13) on reply card.

Corrosion Inhibitors

Tretolite 8-page brochure explains application methods of corrosion inhibitors to oil and gas well systems. Schematic drawings, graphs, and photographs are used throughout brochure to describe product and its applications. *Tretolite Company.*

Circle number (14) on reply card.

Replacement Air Filter

Four-page, illustrated bulletin describes Union Carbide Development's replacement air filter. Two-color bulletin tells how the cube filters can reduce filter bank face area by more than half. Physical process of reverse loading, primarily responsible for high efficiency and long life of the ULOK filter unit, is described in detail.

Exploded-view illustrations show how the four components are assembled prior to installation in a filter bank. A diagram illustrates typical arrangements, and a data table lists the capacity and resistance of each of the dozen filter sizes.

Low cost and easy installation are among eleven over-all features highlighted. *Union Carbide Development Company.*

Circle number (15) on reply card.

Packaged Centrifugal Air Compressor

New, 20-page Bulletin 175 introduces the Clark Isotemp Packaged Centrifugal Air Compressor line for air separation plants and industrial use. In addition to detailed engineering data which permits approximating horsepower requirements for various applications, the brochure incorporates complete illustrations and descriptions of all major design features, including multi-stage compression with high efficiency volutes and impellers plus other characteristics.

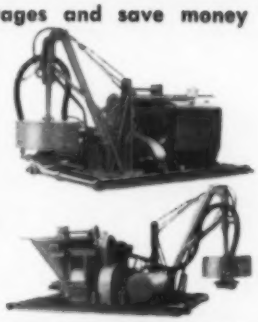
Compressors are built in six frame sizes with hp ranges from 1000 to 8000 bhp, and capacities from 5000 to 38,000 cu ft per min. *Clark Bros Co.*

Circle number (16) on reply card.

New Mudmixer Makes Other Mixing Methods Obsolete and Costly

***Compare* Thompson's field proved advantages and save money**

Automatic feed and mixer gives close control of dry muds and chemicals (except caustic soda) and mixer delivers mud to system thoroughly mixed. Actual field tests have proven an *increase in jel yield of 15% to 30%* over hand feed and jet mixing methods. Thompson Mud and Chemical Mixer is a complete unit with pump and power.



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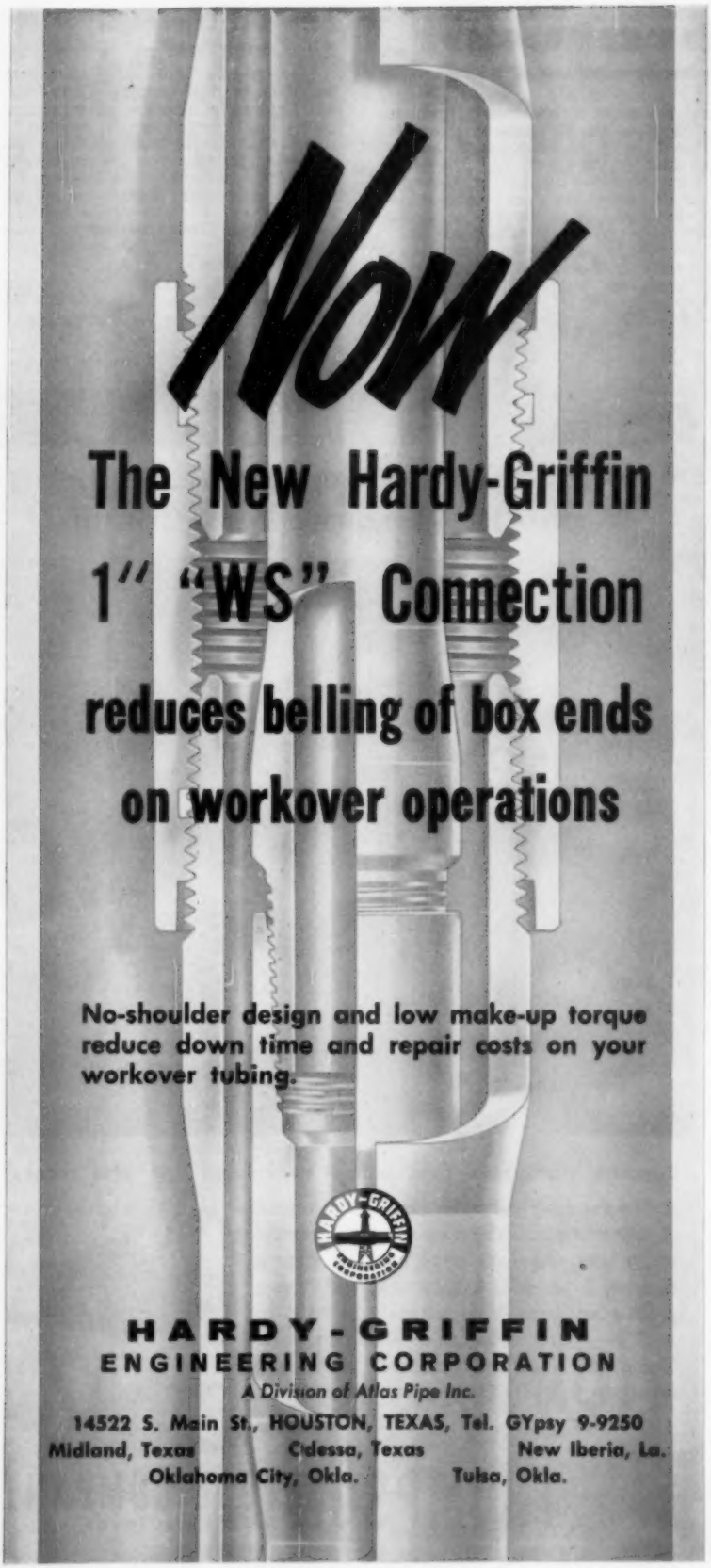
THOMPSON TOOL COMPANY
Iowa Park, Texas



Now

The New Hardy-Griffin 1" "WS" Connection

reduces belling of box ends on workover operations

No-shoulder design and low make-up torque reduce down time and repair costs on your workover tubing.

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ENGINEERING CORPORATION
A Division of Atlas Pipe Inc.
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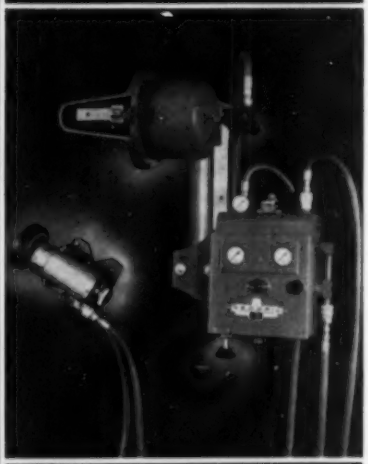
Midland, Texas Odessa, Texas New Iberia, La.
Oklahoma City, Okla. Tulsa, Okla.

The NEW GEODRIL® AUTOMATIC DRILLER



gives you

1. LONGER BIT LIFE
2. FEWER TRIPS
3. STRAIGHTER HOLE

The GEODRIL Automatic Drilling Control was developed, tested and proved in the field by The Geograph Company, manufacturers of the internationally accepted Geograph Mechanical Well Logging Recorder.

The new, automatic GEODRIL control has many outstanding features and offers the drilling contractor dependability, economy and safety.

Service for the GEODRIL Control is provided by the experienced personnel of Geograph Oil Field Services. Their reputation for service is backed by over a fifth-of-a-century of experience in the oil fields.

When you drill your next well, specify the NEW GEODRIL Automatic Driller for maximum drilling efficiency. For additional information, contact your nearby Geograph Oil Field Services office.

GEODRIL® AUTOMATIC DRILLER

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OIL FIELD SERVICES
P. O. Box 1276 • Oklahoma City 1, Okla.

Let R-u-b-b-e-r Take The Wear

in your sucker rod pumps

IT COSTS YOU LESS THAT WAY

- MARTIN RUBBER & DUCK RINGS give excellent life in dirty abrasive fluids . . . high or low gravity . . . much or little water . . . shallow or deep wells. They last for years in the easier pumping wells. Replacement rings cost comparatively little.
- MARTIN PLUNGER BODIES, precision grooved, drilled and threaded (no underneath fluid passage), usually last for years. Tube or barrel costs are often cut in half.
- The replaceable SYNTHETIC RUBBER GUIDES in MARTIN CAGES last longer than any metal, and the cushioning of the ball increases your ball & seat life. Results are often truly amazing. (Patent No. 2,591,174)

Write for our new 1960 catalog or see it in the new Composite (24th Edition). All products sold thru supply companies.

JOHN N. MARTIN

Manufacturer

9 W. BRADY STREET • TULSA, OKLAHOMA

SUPPLIERS' PARADE

Clark Bros. Company has announced the appointment of James H. Bews as manager of its San Francisco branch. He will be responsible for the sales of engines, compressors, and gas turbines in the San Francisco and Pacific Northwest areas.

J. H. Bews

Dr. B. W. Gamson

Byron Jackson Tools, Inc. Dr. B. W. Gamson has been named vice president in charge of new products development. He moves to his new post in Los Angeles from the company's central research and development facility at Des Plaines, Illinois, where he was associate director of the center.

Cameron Iron Works, Inc. James F. McKeighan, Jr., has been made general sales manager of the special products division.

Dorr-Oliver Incorporated has transferred Robert E. Hochscheid from Johannesburg, South Africa, to a newly-established office in Santiago, Chile, as technical representative. He will cover Ecuador, Bolivia, Peru, and Chile.

McEvoy Company. Mac Wendell Miller has been named sales representative for the company in the Dallas-Fort Worth and North Texas area.

Magnet Cove Barium Corporation. W. C. "Red" Rye has been promoted to regional manager, Texas Gulf Coast.

Hardy-Griffin Engineering Corporation. A. H. Quay has joined Hardy-Griffin as director of technical services. He will be stationed in division headquarters, Houston.

Wilson Supply Company. Jimmy T. Watson has been made assistant to the manager of stores. He served as store manager for the company at New Iberia and Beaumont, and he was the district manager for the East Texas-North Louisiana area with headquarters in Beaumont.

J. T. Watson

B. N. Hogan

Republic Supply Company. Ben N. Hogan has been named manager of Republic's Houston sales office, and John P. Rhodes has been made manager of the Dallas and Fort Worth areas.

NEW ECONOMY

In Payne Automatic Pump Accumulator Units for Blow-Out Preventer Operation

The new Payne Type "E" automatic pump accumulator unit has solved three basic problems confronting drillers today – increased safety, easier handling and reduced cost.

Because the Payne non-separator type accumulators need not be removed for field service, they are used as vertical structural members of the unit, welded in place on the skids as the main sections of the assembly.

The Type "E" design produces a much stronger arrangement which remains in perfect balance. In transportation and rig placement this new center of gravity simplifies all handling procedures.

Payne Type "E" Automatic Pump Accumulator Units are available in all popular sizes from 20 to 80 gallons with Payne Two-Stage-Double-Acting-Pump and Automatic Unloading Valve.

Fluid control manifolds are supplied with ¾" 3000 psi W.P. stainless steel Ramlok 4-way valves. Automatic controls and pumps are protected by steel covers, heavy duty skids and lifting eye are provided for safe handling.

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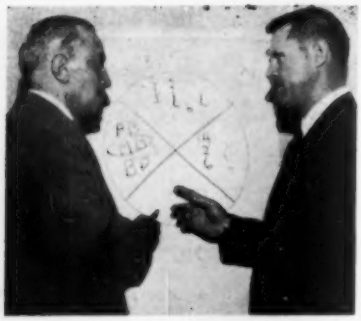

Techno-economics, application of the most up-to-date scientific techniques in both management and technology, is a term often used by Dr. Richard Woodbury, left, of the **Southwest Research Institute** in San Antonio. A three-day seminar, conducted recently by Dr. Woodbury for **Weatherford Oil Tool Company, Inc.**, was attended by Weatherford personnel from many parts of the world. With Dr. Woodbury is Jess E. Hall Jr., president of Weatherford. Sessions held in Houston and San Antonio concerned long-range planning for company's corporate development.

Drilling & Service, Inc. has promoted two executives. James Cowan has been appointed Oklahoma division manager, and R. D. Oliver, who has been named division manager in charge of the New Orleans office.

Harley Sales Company has been selected as the Oklahoma distributorship for the complete line of Worthington Corporation's horizontal reciprocating plunger pump with a complete stock of pumps and parts immediately available.

Harley maintains a warehouse and service organization in Tulsa, Oklahoma; Wichita, Kansas; and Houston, Texas.

Halliburton Oil Well Cementing Company has received shipment of General Electric's first fracturing powerplant package. Powerplant will be evaluated in oil well fracturing service by Halliburton.

Dresser Industries. J. D. Mayson, formerly secretary of the company, has been promoted to vice president and secretary of Dresser in Dallas. He will now direct the legal, tax and insurance activities for the company.

F. H. Maloney Company. Two new directors have been elected—B. Hunter Loftin and Ray F. Weston Jr., who was also named secretary-treasurer of the company. William B. Campbell, technical services director, was made vice president for technical services.

Dowell has opened a service headquarters in Punxsutawney, Pennsylvania. Howard Waugh has been transferred from Charleston, West Virginia to be manager of the new office. D. L. Brehm and B. L. Chisler have joined the office as service sales engineers from Flora, Illinois and Killbuck, Ohio.

R. W. Vutech has been transferred to Charleston, West Virginia to succeed Waugh.

California headquarters for Dowell have been opened in Bakersfield, and D. J. "Don" Mack is manager. J. W. Clifford, Jr. is in charge of Bakersfield operations and J. B. Ritchie is the service sales engineer.

Schlumberger Well Surveying Corporation. Charles F. Gallagher has been named manager of the North Louisiana division for Schlumberger. In his new capacity Gallagher will make his headquarters in Shreveport, Louisiana.

Continental-Emsco Company. A new shop building for reconditioning and assembling used equipment has recently been completed at the Odessa, Texas, used equipment depot of Continental-Emsco.

The 46 by 100-ft steel building is equipped with a 7½-ton electric hoist which travels the length of the building, a heated vat, stationary steam cleaner, hydraulic press, and electric grinder.

Hunt Tool Company. Jack G. Clark has been appointed superintendent of the Houston plant, and Jack T. Rodgers has been made assistant secretary-treasurer.

Baash-Ross Division. Ben A. Hilliard Jr. has been appointed domestic sales manager. He will have his office at company headquarters in Houston.

B. A. Hilliard

G. R. Hodgson

Bowen-Itco, Inc. G. Reid Hodgson has been appointed director of engineering and research. Hodgson will direct all research and development of new oil field specialty tools and supervise production engineering and quality control of all products.

HOMCO. A service branch has been opened in Ruston, Louisiana. Store is equipped to furnish complete fishing and cutting, directional drilling, electrical well services and oil field rentals. Warren Magee has been named district manager and L. B. Dennig has been named district fishing and cutting representative. Carrol L. Cole is the electrical well service supervisor and W. W. Parks, warehouseman.

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6. **Ordinary clay base drilling mud.**
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8. **Advance water flood procedure.**
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Hydrofluoric Acid Anhydrous
Hydrofluoric Acid Aqueous
Hydrofluosilicic Acid
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Lead Fluoborate
Lithium Fluoride
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Potassium Bifluoride
Potassium Chromium Fluoride
Potassium Fluoborate
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Potassium Titanium Fluoride
Silico Fluorides
Silicon Tetrafluoride
Sodium Fluoborate
Tin Fluoborate
Zinc Fluoborate
Zinc Fluoride

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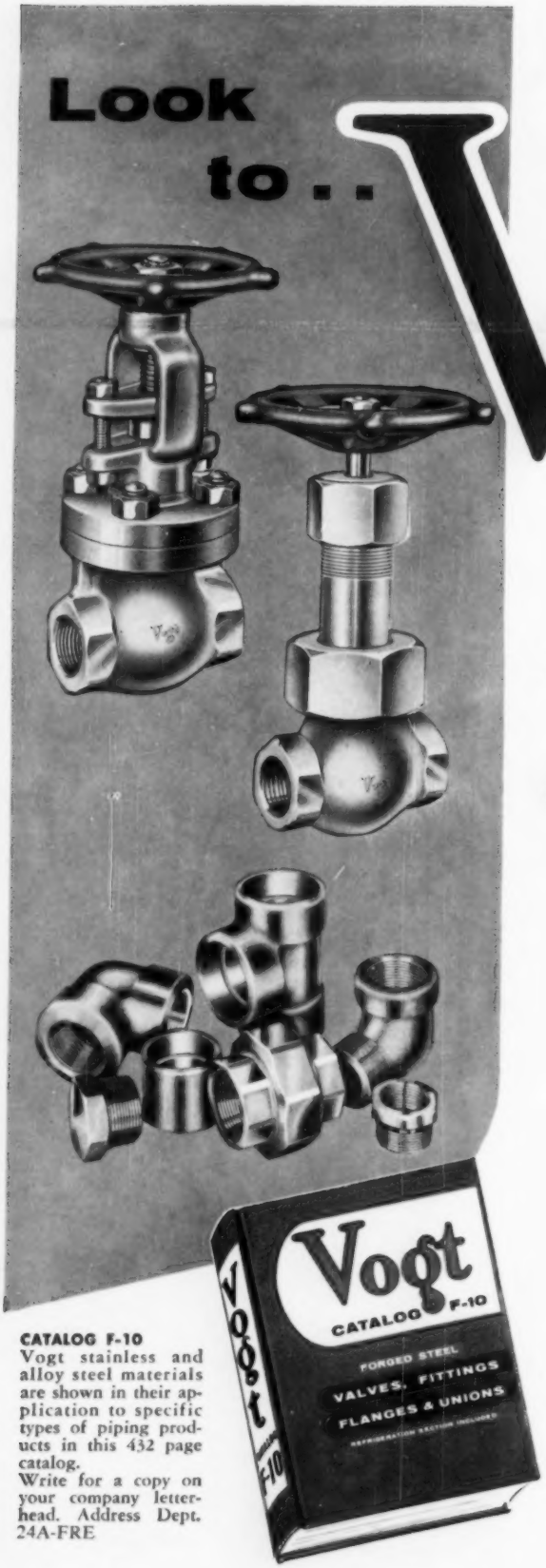

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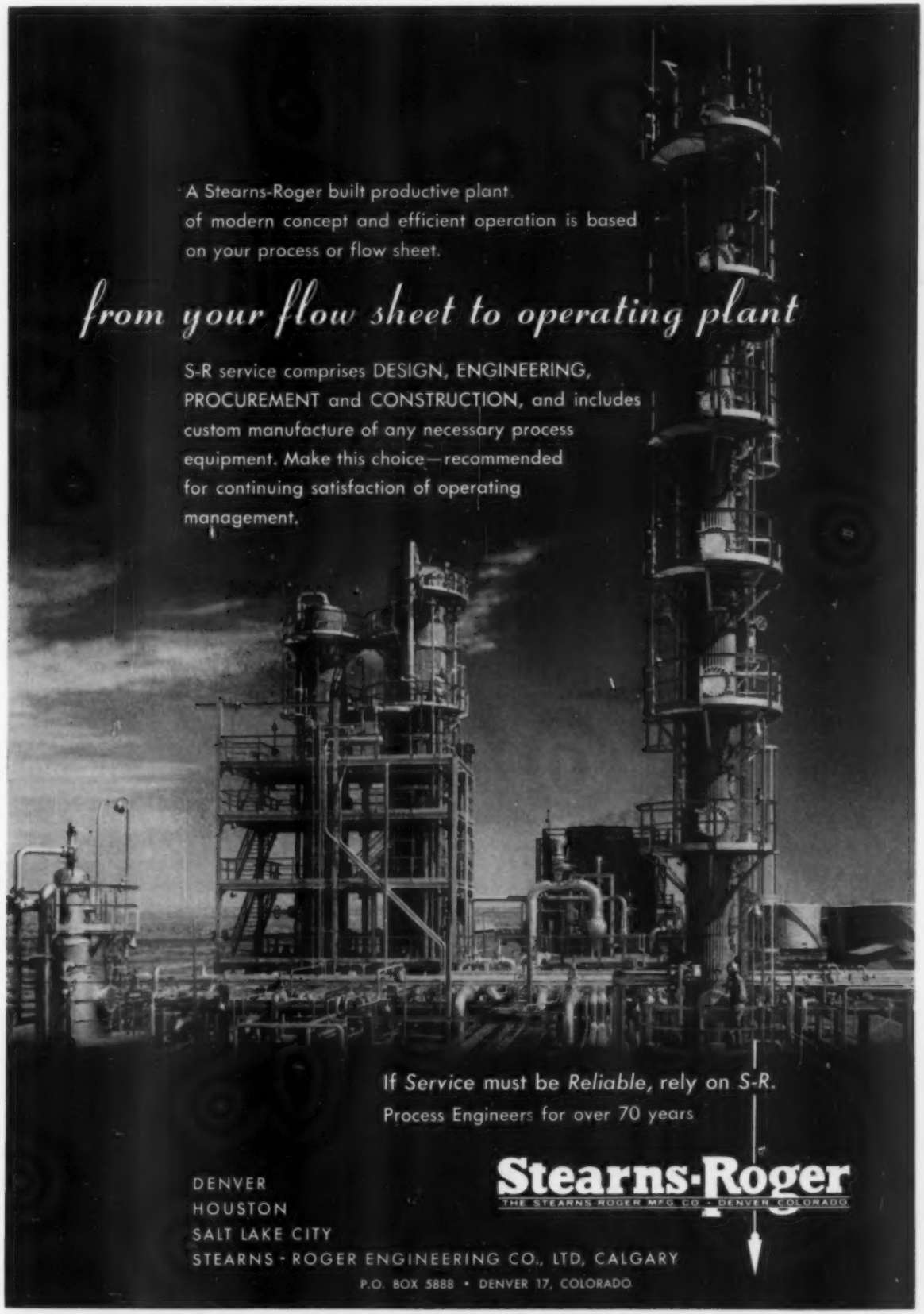
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How premium blend stocks perform on the road

Recent work by Ethyl Research pinpoints effects of component concentration and component boiling range on road performance

by **E. J. FORSTER,**
Refinery Technology Division, Ethyl Research Laboratories, Detroit, Michigan

THIS recent study, conducted by Ethyl Research for a specific refiner, produced two broad conclusions on the performance of premium gasoline components which are of interest to the entire refining industry:

1. Gains in Research octane number that are achieved through increasing the severity of catalytic reforming are not fully realized in terms of antiknock performance on the road.

2. When catalytic reformate is split and the bottom cut of the reformate is blended to premium gasoline, the wider the boiling range of the bottom cut, the better the road performance of the fuel relative to its Research octane number.

Ethyl Research was able to predict accurately the results of the study because increasing reforming severity also means increasing the aromatic content and, therefore, the fuel sensitivity (Research octane number minus Motor octane number).

Why These Conclusions Are Important

Efficient use of high octane blending stocks is very important to the refiner because of the octane improvement costs of current premium gasolines.

Optimum antiknock quality must represent an economic balance between both Research octane and Road octane. This must be continually reviewed because of the alternate methods for octane improvement available to the refiner.

For example, one alternate is splitting certain stocks such as catalytically cracked naphtha and reformate. Fractionation facilities are best used for this purpose when the optimum boiling range to blend for road performance is known.

Similarly, it is helpful to know the effect of increased reforming severity upon road performance, the effect of the addition of alkylate upon road performance, the effect of boiling range of catalytic naphtha and other factors that affect premium quality.

Ethyl's Test Program

Twenty-seven test blends were designed from base stocks shown in the opposite table to study various effects of base stock concentrations, reforming severity, and boiling range. Sixteen blends were composed of combinations of various catalytic naphthas and reformates. From these, two blends were selected because of their respective superiority with regard to either Road octane number or depreciation. Various percentages of alkylate, straight-run or polymer then were added to each of these reformate-naphtha base blends. Blends were leaded to a concentration of 3.0 ml TEL/gallon and butane was used to pressure blends to 10.0 lb. Reid vapor pressure.

Both Modified Uniontown and Borderline road ratings were conducted in three passenger cars.

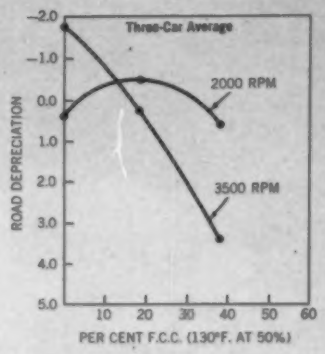
1959 VEHICLE	COMP. RATIO
A	11.1-1
B	10.7-1
C	10.1-1

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

BASE STOCKS USED AS COMPONENTS IN TEST BLENDS

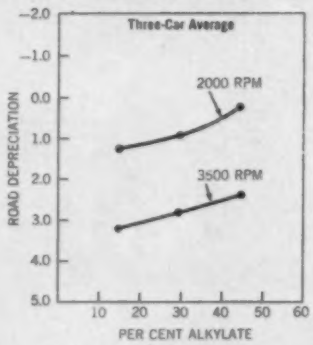
1. F.B. (Full-boiling) Cat Reformate (100 RON @ 3.0 ml TEL)
2. Heavy Cat Reformate (30% Bottoms, F.B. = 100 RON @ 3.0 ml)
3. Heavy Cat Reformate (70% Bottoms, F.B. = 100 RON @ 3.0 ml)
4. Heavy Cat Reformate (30% Bottoms, F.B. = 102 RON @ 3.0 ml)
5. Heavy Cat Reformate (70% Bottoms, F.B. = 102 RON @ 3.0 ml)
6. Light F.C.C. Naphtha (50% Evaporated @ 130°F)
7. Light F.C.C. Naphtha (50% Evaporated @ 180°F)
8. Full-boiling Alkylate
9. Light Straight-run
10. Catalytic Polymer

Effect of 130° Cat Naphtha on the Road Depreciation of Full-Boiling 100 RON Reformate



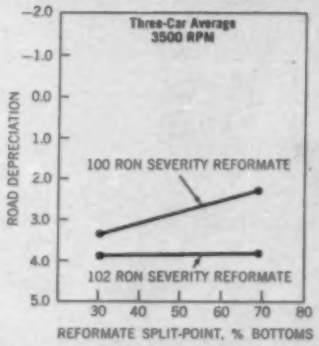
Up to 20% cat naphtha raised the low-speed (2,000 RPM) Road octane performance and consequently reduced depreciation (Research octane minus Road octane). At high engine speeds, the presence of cat naphtha in any amount results in depreciation which increases as the percentage of naphtha increases.

Effect of Alkylate on Road Depreciation Base Blend Composition: 40% 180° F.C.C., 60%-30% Bottoms 102 Ref.



The addition of alkylate reduces road depreciation and thereby emphasizes the important effect of sensitivity on road performance.

Effect of Reformate Boiling Range and Severity on High Speed Road Depreciation



At any given split-point a change in reforming severity from 100 to 102 RON results in greater depreciation at high speeds.

How Ethyl Research works for you

Ethyl Research Laboratories in Detroit are continually investigating the variables that affect gasoline performance. Frequently, special studies are made for individual customers that are of interest to the entire industry.

An example is the new research report, "Road Antiknock Behavior of Premium Blends." This is available through your Ethyl Representative or send your request to: Ethyl Corporation, 100 Park Avenue, New York 17, New York.

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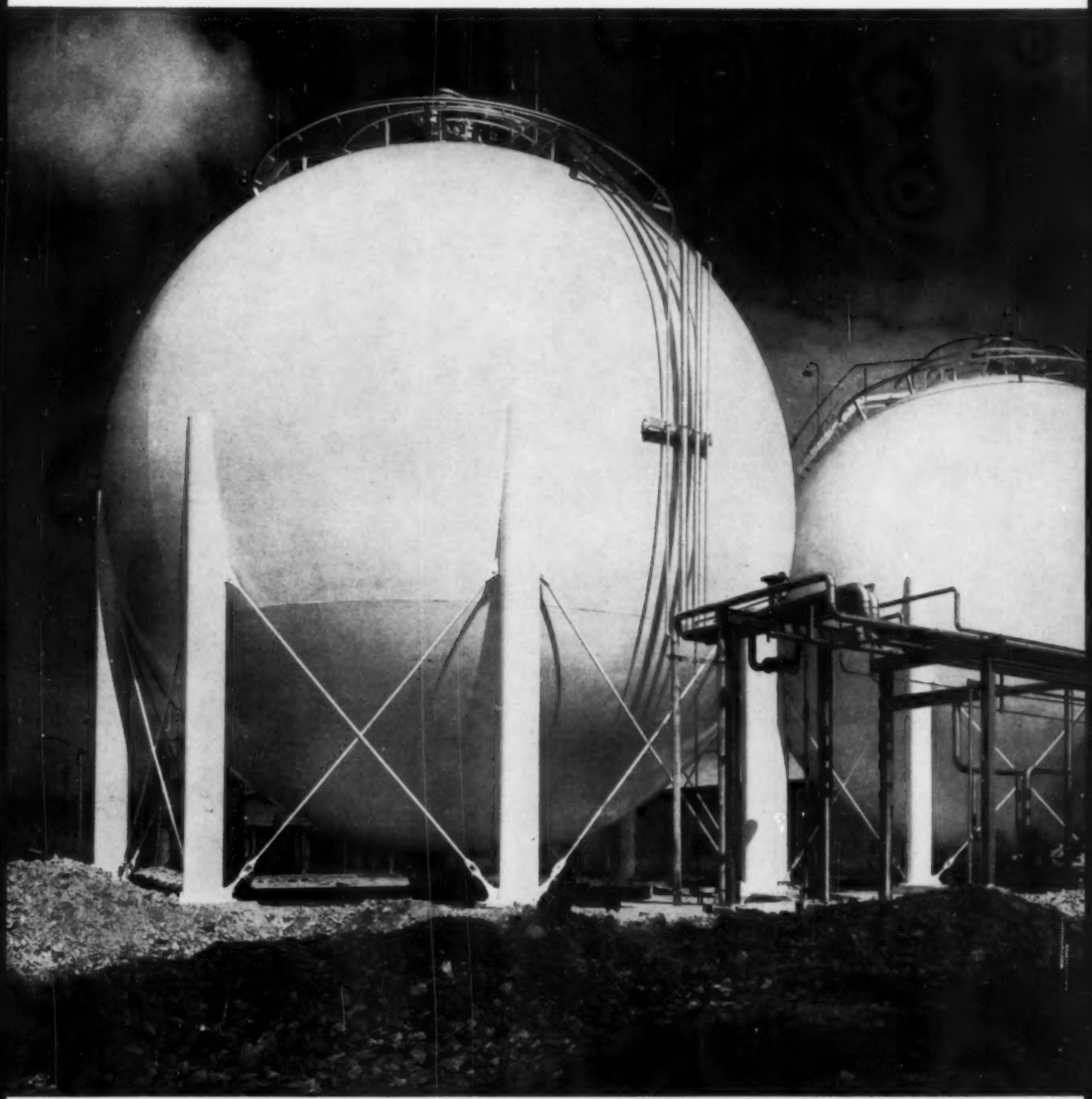

Hortonspheres built of USS "T-1" Steel for Compania Cubana Del Nitrogeno, S. A., Matanzas, Cuba. Designed, fabricated and erected by Chicago Bridge & Iron Company.

This mark tells you a
product is made of modern Steel.

Weight cut 50%

in USS "T-1" Steel pressure vessels

Each of these two Hortonspheres in Matanzas, Cuba, has a capacity of 8,750 barrels of anhydrous ammonia. They are 45.5 feet in diameter and each shell weighs about 311,350 pounds. By designing them with USS "T-1" Constructional Alloy Steel, to an allowable working stress of 32,400 psi, the plate thicknesses were reduced to 1.109 inches and 1.075 inches. This is about 50% less than if A212-Grade B fire box quality steel had been used.

Result: Only 363 tons of USS "T-1" Steel were needed for both tanks, reducing by one-half the amount of steel that would otherwise have been required. Freight, handling, welding and erection costs were less—and the user got a stronger, tougher vessel with an overall saving in cost.

Fabrication steps: Plates of USS "T-1" Steel in widths of 78 inches and 115 inches, and in lengths up to 19 feet 2-1/2 inches, were shaped cold and field stress relieved. Column plates and some shell plates were stress relieved in the shop. Electrodes used in field welding were low hydrogen type of the E110 strength level and all field welds were 100% radiographed. With a minimum yield strength of 100,000 psi, plus toughness, weldability, and high resistance to impact abrasion, USS "T-1" Steel is ideally suited for many applications throughout industry. Write for our latest booklet. United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania. *USS and "T-1" are registered trademarks*

Hortonsphere is a registered trademark of Chicago Bridge & Iron Company

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
National Tube—Pittsburgh
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company
United States Steel

economic evaluation

ECONOMICS AND COST ESTIMATION are still too often neglected subjects among engineers. Technical magazines will in many cases emphasize the details of optimization calculations using modern high speed computing equipment but spend little attention on exactly what is to be optimized. Management-type magazines or those published by leading business schools will feature articles that enable investment decisions to be made but treat the investment itself as an unchangeable amount of capital, the details of which are not to be scrutinized by executives. But to arrive at an economic optimum in the design of a refinery or petrochemical plant, both economic and technical factors must be combined. This issue of *Petro/Chem Engineer* will give you a series of articles written in an attempt to cover some of this middle ground between purely business and purely scientific approaches to the problem of engineering design.

The articles presented are roughly intended to fall into three categories:

- *Estimating costs of hydrocarbon process plants.*
- *Determination of profitability of alternative investments.*
- *Examination of equipment details in the light of acceptable economic performance.*

Regarding plant costs the aim was especially to bring out factors often overlooked in the conventional approach, especially those involving the human element. One of the papers dealing with profitability is a general survey of the usually employed methods. Another presents a new index of attractiveness and shows how the same index can be consistently applied to the problem of economic design of process plant components. Other papers show in detail how economics may be brought into typical unit operations.

It is hoped that this series will not only be useful to practicing engineers but to those who are recent graduates of engineering or scientific schools. All too often the technical graduate leaves school with an excellent set of mathematical and scientific tools but only a vague conception as to how to use this basic information in solving the problems of the industrial organization which employs him. Sometimes it takes years before he realizes that in designing a distillation tower more is involved than an elaborate series of plate-to-plate calculations. Such truisms as "*the engineer can accomplish for one dollar what anyone can do for two*" are not immediately useful in telling the young engineer exactly how to go about accomplishing the desired end.

— DR. JOHN HAPPEL, P. E.

Dr. John Happel, P. E., Special Issue Editor

Dr. John Happel, *Petro/Chem Engineer's* special issue editor for August, is a prize example of what can happen when you give a 10-year-old boy a chemistry set.

In Happel's case the chemistry set was a catalyst that aroused his interest and propelled the Brooklyn-born youngster into a distinguished career as a chemical engineer . . . both in industry and head of the chemical engineering department at New York University.

Happel began his engineering studies at the Massachusetts Institute of Technology, completing his BS in 1929, and stayed an additional year to get an MS in chemical engineering practice.

Then he went to work for Socony-Vacuum Oil Co., where his technical assignments included pilot plant and lab tests, designing refineries for foreign countries, and running a fleet of cars to test gasoline. After 10 years he was in charge of about 50 technical people.

During World War II he was a member of the Petroleum Industry War Council and made a detailed study of butane dehydrogenation of production of butylenes to be used in aviation alkylate production. Later he became a member of the technical committee responsible for design and initial operation of the world's largest butadiene from petroleum plant, at Port Neches, Texas.

After the war he returned to Socony, which was then considering production of petrochemicals, especially ethylene. However, at that time the company was more interested in finding oil, since they could get more pay-off on production in the Middle East than on petrochemicals.

Happel had been considering teaching for a long time but never had firmly resolved to get a doctor's degree until the late 1940's, when he started to study nights at Brooklyn Polytechnic Institute. Finally he took a year's leave of absence to complete his thesis, and was awarded the degree of Doctor of Chemical Engineering in 1948. He joined the NYU faculty in the fall of 1948 and since 1949 has been chairman of the department.

NYU ranks among the top half dozen schools in the country in the number of doctor's degrees granted in chemical engineering. The school's large chemical engineering research program — between $500,000 and $600,000 a year in sponsored research — has enabled Happel to continue his work and gives opportunity for the kind of practical experience that students ordinarily cannot get in a college lab. Research grants also have provided money for equipment, including two mass spectrometers, two infrared spectrometers, and several gas chromatography units.

Happel has continued to do research and consulting in the field of petrochemicals, especially production of unsaturated hydrocarbons and their derivatives. He is particularly interested in catalytic processes involving contacting of fluids with solids and in the economic evaluation of new process designs.

He is author of the book *Chemical Process Economics* (John Wiley and Sons, New York, 1958) and of numerous technical papers and book chapters on such subjects as gasoline manufacture, production of acetylene, and extractive distillation. He is in the process of writing a book on the hydrodynamics of slow viscous flow, especially as related to particulate systems.

Happel is also credited with a score of U.S. patents on petroleum subjects as well as patents in nine foreign countries.

He is a member of the American Chemical Society, American Institute of Chemical Engineers, American Institute of Chemists, American Rocket Society, Alpha Chi Sigma, Sigma Xi, Phi Lambda Upsilon, and Tau Beta Pi and is a licensed professional engineer in New York State.

Happel is married to the former Dorothy Merriam, a concert violinist who for the past several years has played in the Lake Placid Club Sinfonietta. The Happels and their three children — Jill, 6; George Syms, 4, and Ruth Emilie, 2 — take off for Lake Placid each June and Happel devotes his summers to research and book writing. "I can work for several hours at a stretch without interruption here," he points out, "and the cool weather keeps me mentally alert." He can get into New York when necessary to take care of business there.

Happel feels that engineering offers the young man of today a unique opportunity to fit some of the accomplishments of this scientific age into a scheme for peace, consistent with the business and political tradition of our society. He points to the fact that engineers are accepting greater social responsibility in addition to purely technical functions.

He also emphasizes the importance of economics to the engineer . . . that it takes more than scientific background to put information to use and make some money out of it . . . the subject to which this issue of *Petro/Chem Engineer* is devoted.

We are honored to have Dr. John Happel, chairman of the department of chemical engineering at New York University and a member of *Petro/Chem Engineer's* Editorial Advisory Council, as special editor for this issue on Cost Estimating and Economical Evaluation. Dr. Happel has obtained the cooperation of the top men in the country in this field and coordinated their efforts to bring you an issue loaded with information of high interest and direct value to you on your job. For his able assistance, *Petro/Chem Engineer* wishes to extend to Dr. Happel very sincere thanks.

Selection of

ROBERT D. NEWTON
Chas. Pfizer & Co., Inc.
Brooklyn, New York

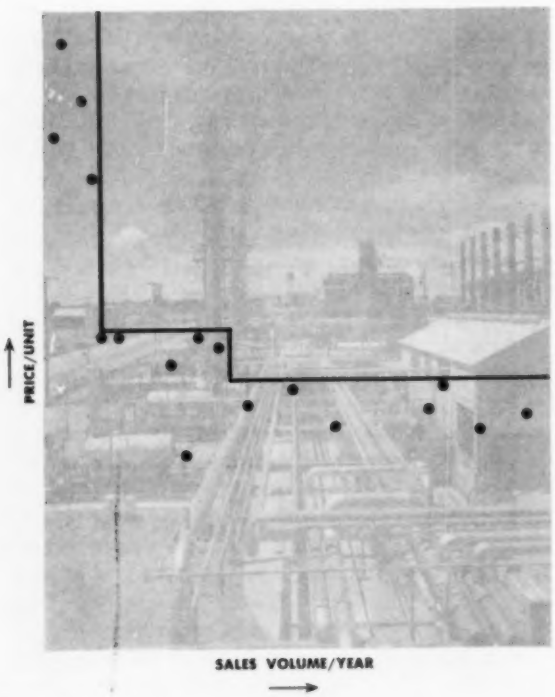

FIG. 1. Exclusion chart.

UNCERTAINTY is the most certain aspect of the future. However, this need not completely preclude contemplation of the effect of variable conditions upon operations when expanding a plant. Expansion is a critical question. It involves not only the protection of the current position, but also the provision of resources necessary to the future position. Usually the operation is already contributing a satisfactory profit return and expansion of the facilities may conceivably jeopardize these earnings by altering the situation.

Often the production level selected for expanding an existing plant is based upon a somewhat arbitrarily selected higher sales volume at the current sales price returning a satisfactory profit. Little consideration is given to the variance of economic conditions over the entire range of expanded volume. Before a new capital venture in plant expansion is undertaken, its economic future should be carefully evaluated. A systematic appraisal presented graphically will often indicate trends and results which might otherwise be overlooked. Over the desired range of market volume the variation of sales price, manufacturing cost, profit, and capital investment should be determined. Selection of optimum plant capacity is thus possible. For the particular plant size selected, the effect of sales price and output changes may be ascertained in a similar manner.

Variation of plant size

Sales . . . The initial step in properly sizing a plant for expansion requires a realistic appraisal of the market for the product. Many cases exist where products have commercially failed simply because the market could not support them. One recent study of a series of product failures revealed that, with the exception of one, all had their basic cause in the area of marketing.

The ultimate aim should be the development of the relationship between price and annual volume. This requires determination of the company's share of the total market at various sale prices. Since the factors involved are in most cases not necessarily controllable by the producer, such a determination is a very difficult question to answer in direct quantitative terms. Fortunately, in the volume expansion of an existing product, considerably more data are available than are available for entirely new ventures. Historic price patterns and market shares by customer groups are known; the product's use, acceptance, and potential have been established, and the effect of competition has been measured.

The sale price, after the contemplated expansion, should provide a satisfactory profit. However, the price cannot be established simply on the basis of marking up the cost to provide a satisfactory profit. Price is representative of the value of the product to the purchaser. Cost, on the other hand, is indicative of the effort expended by the producer in conducting his business. Since the purchaser is in no way concerned with the producer's problems, any purely artificial mark-up over cost in establishing sale price may prove misleading. Competition, substitutes, and usefulness — over

which the producer can exercise relatively little direct control — can have notable effects on pricing in a free economy. Even though the product may possess a wide potential market, competitors' countermeasures to price changes and sales volume increases must be contemplated and the effect postulated. As the demand for a product is stimulated, increased productive capacity and improved process techniques frequently join to reduce costs, and combined with increased competition lower prices may result. In turn, new markets and uses may be attracted.

The use of the exclusion chart, as shown in Fig. 1, may prove to be valuable in relating price to volume. The procedure in constructing an exclusion chart simply involves plotting the current prices of the various products in a particular market segment versus their annual sales volumes. From such a diagram certain price-volume relationships are obviously excluded from practical attainment. Frequently, a series of exclusion charts based upon data from past time intervals may exhibit useful trends.

While the problem of developing a price-volume relationship, for a product on which expansion is contemplated, is plagued with intangibles, perceptive study supplemented by judicious assumptions will permit its establishment. Fig. 2 shows one possible form which the price-volume relationship can assume.

Capital investment . . .The capital investment should be estimated over the entire range of contemplated sales volume. Expanded plants usually achieve higher capacity through the use of both large singular units and multiples of small pieces of equipment. The degree to which multiples are employed rather than single units depends upon the maximum size of equipment that can be obtained or designed, the largest size of equipment usable due to process limitations, the flexibility desired in production rates, and the frequency of mechanical failures.

Generally, expanded plants are composed of a greater proportion of small multiple units than would be employed for completely new facilities of a total capacity equal to that of the total expanded installation. This usually is necessary in order to achieve integration with existing facilities. The higher cost of duplicate units is offset somewhat by closer design specifications resulting from the experience gained from the operation of the original plant. Furthermore, the investments required for nonproductive components, such as buildings and utilities, may be as much as one-quarter less than that required for a new plant.

ROBERT D. NEWTON of the legal division of Chas. Pfizer & Company, Inc., is author of the book *Chemical Engineering Cost Estimation* and of many articles on economic evaluation and operations research. He holds bachelor's and master's degrees in chemical engineering from Rensselaer Polytechnic Institute and has been with Pfizer since 1946, serving as production supervisor, in the production headquarters staff, and in the operations research department before assuming his present position this year. He is a member of the Operations Research Society of America, the Institute of Management Science, American Association of Cost Engineers, American Institute of Chemical Engineers, and the Society of Sigma Xi.

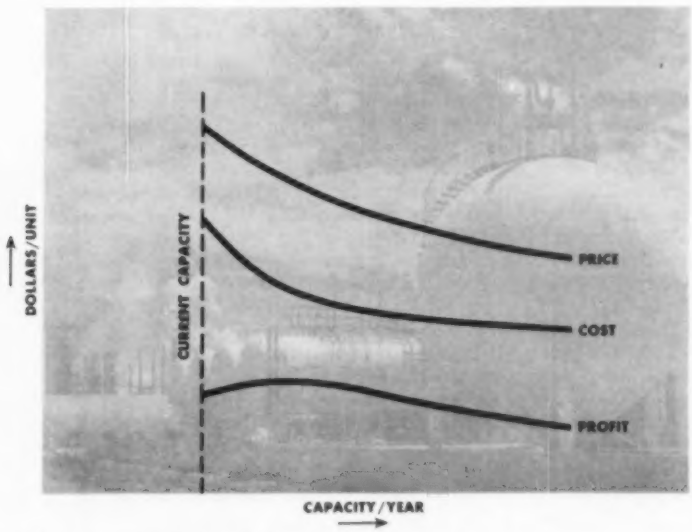

FIG. 2. Unit price, cost, and profit versus annual capacity.

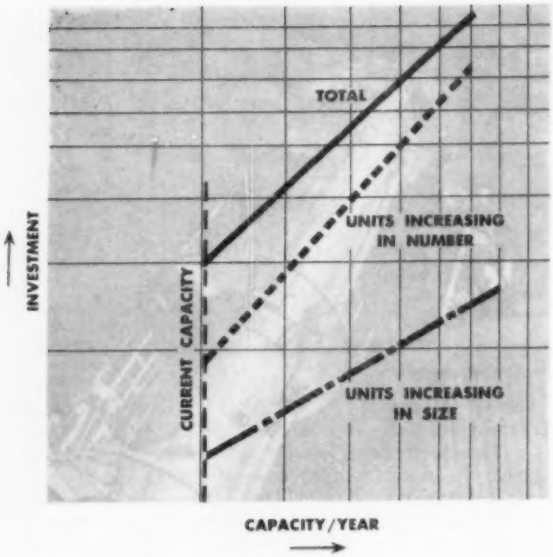

FIG. 3. Investment versus annual capacity.

Although in a static economy, the total investment for a plant which has undergone expansion is usually greater than that for a new facility constructed from the same level of total output, the effect of inflation upon plant construction costs has in practice made expansions economically attractive in comparison to the alternative of completely new facilities.

The price of process equipment has been found to vary with the capacity to a fractional exponential power. While considerable variation in the value of this power term exists between different types of equipment, it generally has been found to average 0.6. Thus, if a reactor is twice the size of another, the cost of the larger will be $2^{0.6}$ times the cost of the smaller unit.

Just as the cost of equipment varies with an exponential value of size, a similar relation has been found to hold true for complete plants. The duplication of equipment, which always exists to some extent in new plants, tends to raise the power term to an overall average of 0.7. Because of the increased tendency toward equipment duplication rather than size increase in expanding existing plants, the investment above that for the original output will be proportional to the capacity raised to a power greater than that for the initial plant. Thus the exponent will take on a value between 0.7 and 1.0.

The components of the capital investment for an addition to a plant should be divided into two parts based upon the way in which each contributes to the increased capacity — an increase in size or an increase in number. By analyzing in such a manner two or three capital cost estimates for plants of varying volume outputs, the investment may be determined over the entire range of contemplated volume and plotted versus the annual capacity as shown in Fig. 3.

Cost . . . Over the considered range of volume the cost of manufacturing and selling the product must be estimated for plants of various levels of annual capacity. Since additions made to existing plants must be integrated with the original facilities, the resultant manufacturing cost usually will assume the characteristics of the original plant. If a major cost reduction is necessary to ensure profitable operation of an expanded unit, in most cases it will not be achieved from an expansion. In such a case, completely new facilities or process revisions should receive prior consideration. While manufacturing cost per unit of output will usually drop to some extent as the capacity of the plant is increased, generally it will not be as low for an expanded plant as it would be for a new installation of the same total capacity. This is due to the greater proportion of multiple equipment employed in facility additions.

Total expenditures for raw materials, utilities, packaging containers, purchased services, shipping, and handling have been found to vary directly with capacity, and thus will be essentially the same per unit of production at all levels of output. Fixed charges and maintenance tend to vary for the plant to the same power of capacity as does the investment. Labor and those items proportional to it, such as supervision, laboratory control, and overheads, have shown a variance of the 0.25 power of the capacity for plants achieving higher capacities through the use of larger sizes of equipment. On the other hand, if the addition consists entirely of multiples of the original unit, then the labor force will increase nearly in direct proportion to the capacity. By analyzing labor needs by these two methods, and combining them with the other components of manufacturing cost, the variation over the entire range of production may be developed as shown in Fig. 4.

Sales expenses can have wide and somewhat unpredictable fluctuations. They may remain constant per a unit output if they are incurred primarily in the physical distribution of goods. On the other hand, a reduction in unit sales expenditure may accompany an increase in volume, particularly if the additional output is to be sold primarily among the present customers, or the additional sales effort required to market the additional production may conceivably increase the unit selling cost.

Estimates of the variable components of costs at two or three points over the range of volume considered will usually prove sufficient to demonstrate the relationship. Thus, the total unit cost may be calculated and plotted as a function of capacity as shown schematically in Fig. 2.

Profit . . . A plot of the difference between the unit sales price and the unit cost at corresponding levels of output

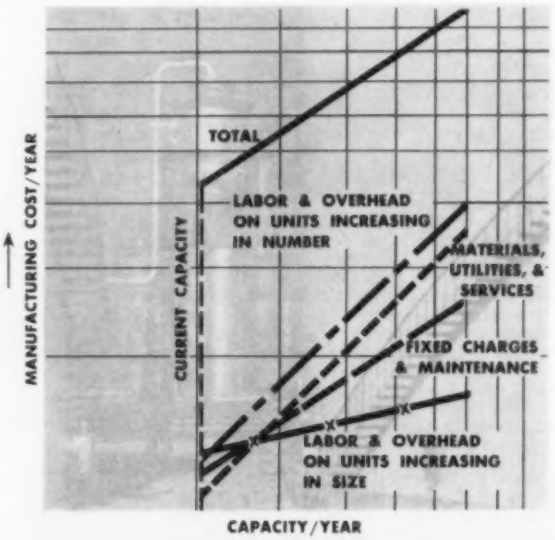

FIG. 4. Annual manufacturing cost versus annual capacity.

will result in a curve reflecting the unit profit earned — or the loss incurred — over the entire range of proposed output as shown in Fig. 2. Profit may be computed on either a before or an after income tax basis, whichever is preferred.

However, maximum unit profit cannot be employed as the measure for selection of plant size. By multiplying the unit profit by the corresponding annual volume the annual profit can be determined and plotted versus capacity as shown in Fig. 5. It is unlikely that the level for maximum annual profit will coincide with that for maximum unit profit. By expressing the annual profit as a percentage of the investment at corresponding capacity levels, a curve of percent return on investment as a function of output can be developed as shown in Fig. 5. While the most elementary form of return on investment has been employed for illustrative purposes, it should be noted that application of some of more sophisticated methods of return may prove to be desirable.

The capacity generating the maximum percent return may differ from that for maximum annual profit. The choice between these two levels can only be resolved by consideration of other investment opportunities. First of all, no level of production should be considered which fails to reach

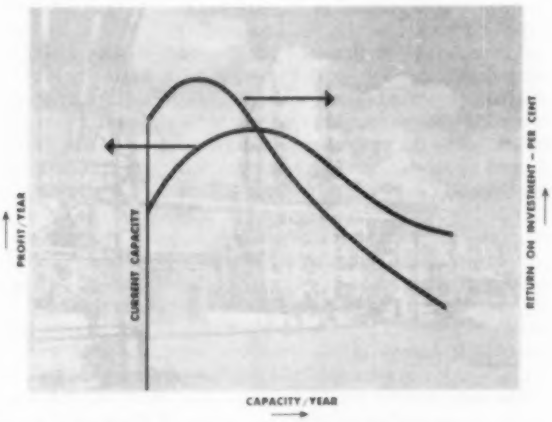

FIG. 5. Annual profit and percent return vs annual capacity.

a prescribed minimum percent return on the investment consistent with the risk involved. If the return is deemed to be satisfactory at the level of annual output which shows the maximum annual profit, then the expansion should be made to this level provided that the percent return at such an output exceeds the return, commensurate with the risk, for any other possible investment which could be made. If this is not the case, the capacity indicated for the maximum percent return should be selected.

Variation of production rate

Once the plant capacity has been selected, the effect upon costs and profits by operation at less than full capacity potential should be ascertained. Most plants usually are not operated constantly at full capacity throughout their productive lives. The availability of additional supplies does not insure that the marketing function of an organization can sell immediately its full output, particularly if this new capacity represents a sizeable increase over the previous

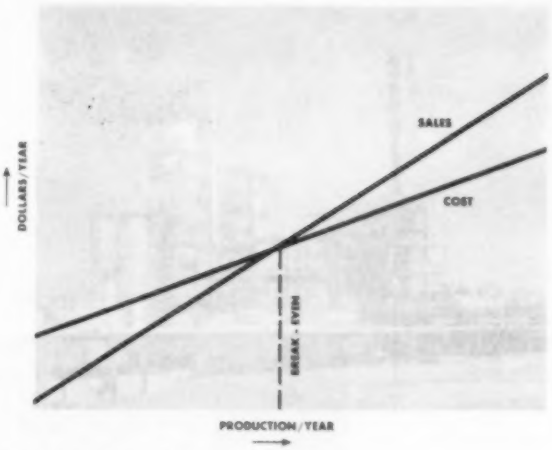

FIG. 6. Break-even chart.

supply. Furthermore, there may be seasonal variations in product demand. Consequently, the variation of profit at different levels less than capacity should be examined. This can be done by what is basically known as a break-even chart. The development and application of these charts has been documented extensively and consequently our discussion will be very limited. Such a chart as shown in Fig. 6 is simply a plot of cost and sales versus production levels for the specified plant size. The intersection of the sales and cost lines is the break-even point. At production levels in excess of this point, the plant will be profitable although not necessarily consistent with the desired return. Expressing the annual profits, at various levels between the break-even point and the maximum capacity, as percentages of the investment, a curve may be developed showing the percentage return as a function of operating level for the plant size selected.

Summary

Selection of the optimum level of plant expansion requires a complete analysis of sales, cost, and investment over the entire range of contemplated output. Use of the mathematical approximations discussed will minimize the number of cost estimates required and yet provide adequate data for prediction purposes. Graphical portrayal over the range of expansion contemplated will permit proper selection of optimum capacity on a basis of maximum profitability. The range of profitable operation of the plant size selected may be indicated by a break-even chart. ★ ★ ★

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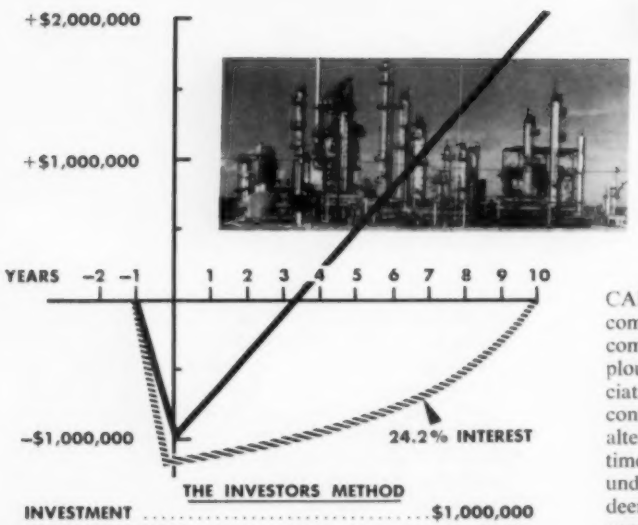
How to measure

J. C. MARTIN,
Research & Development Department,
The Atlantic Refining Company,
Philadelphia, Pennsylvania



THE INVESTORS METHOD

INVESTMENT	$1,000,000
EXPENDITURE TIME	1 YR.
PLANT LIFE	10 YR.
PROFIT & DEPRECIATION	$300,000/YR.
SALVAGE VALUE	NONE

FIG. 1. The Investor's Method.

CAPITAL EXPENDITURES provide the foundation for a company's future efficiency and competitive strength. Many companies have doubled or more in size over the last decade, ploughing back into the business retained earnings, depreciation reserves and often additional outside capital, and are continuously faced with the problem of choosing between alternate possible capital projects. However, at any given time most companies either do not have sufficient funds to undertake all the projects which have been considered and deemed profitable, or an organization of sufficient size to competently exploit all such projects.

It is the aggregate wisdom of a company's capital expenditure program which determines in large measure the company's future growth and earning power. A proper evaluation of all the facts — many of them complex, technical, and illusory, blended with a fair measure of good judgment and a bow to good fortune are necessary requisites for a profitable enterprise.

The first requisite then is the procedure which will indicate the most economically attractive project of the several possible alternates for funds and its overall contribution to the earnings of the company. To assist in developing this, an example project will be set up, (Project A), then various methods or indices used for indicating relative profitabilities or desirabilities of projects will be developed and compared.

A cost and profit summary for our hypothetical project "A" is given by Table 1, which summarizes the cost items involved. Material costs are credited with the value of the by-product to obtain the net material cost of the product. Manufacturing costs comprise the additional labor, maintenance of plant and utilities occasioned by the installation of the process.

The various overheads are accumulated as one item and should represent only the forecast as to how much overheads will actually increase as a result of installing the project. Allocation of old or existing overheads is not pertinent in determining the justification for a new project, — its role is in developing product costs and selling prices once the project is in the line. Depreciation has been taken on a straight-line basis of $100,000 per year. The total product cost involving net material cost and total manufacturing cost is subtracted from income less marketing and transportation expense to arrive at profit before income

project profitability

tax of $200,000 per year. After 50 percent income tax, the net profit from our Project "A" becomes $100,000 per year. Investment has been set at $1,000,000 and working capital assumed at 15 percent of investment or $150,000.

The problem now will be to relate the various factors involved to methods used to illustrate and convey to management the desirability of the project. For the moment and for simplification of comparison, we will omit consideration of income tax and working capital, both of which should be considered in the final determination of the economic worth of the project. The key numbers to keep in mind are the $200,000 per year gross profit, the $100,000 per year depreciation being accumulated for replacement of the facilities and the $1,000,000 investment figure.

How economically desirable is this project? A common denominator is needed to compare this project with alternative projects having essentially the same end purpose, or with other unrelated projects within the company which may be vying for the same capital.

An analysis of mutually exclusive alternatives would involve one or more similar calculations. Table 2 compares Project "A" with another similar project, "B," only one of which can be installed. The net dollar value of the variations in material, manufacturing cost, and income represents the advantage for the differential investment. An index of return can be developed for each individual project as well as for the differential investment. The return for the differential investment is thus revealed more clearly than by inspection of the respective returns from the two large projects alone. As industry becomes more complex the alternatives become more numerous and many times detailed and involved alternatives are required for comparison. It is vital, however, that all the pertinent alternatives be recognized. One of the ways an economic analysis can miss the mark is by the omission of an alternative which is really better than the ones which have been considered.

The commonly used term **"return on investment"** is generally employed to indicate the economic attractiveness of a given project. Let's see now the result of the application of several methods currently in use to Project "A."

Pay out method

The pay out time is probably the most widely used index of project profitability. It is the number of years required

TABLE 1. Cost and Profit Summary Project "A."

	$/year	
Material Cost		
Raw material debit	200,000	
By-product credit	50,000	
Net material cost	150,000	
Manufacturing Cost		
Labor,— maintenance, utilities	250,000	
Overheads	150,000	
Depreciation	100,000	
Total manufacturing cost	500,000	
Total product cost	650,000	
Income less marketing expense	850,000	
Profit before income taxes	200,000	
Net profit after income taxes @ 50%	100,000	
Investment		$1,000,000
Working capital		150,000
Return		

TABLE 2. Cost and Profit Summary Project "A" vs "B."

	$/year		
	Project A	Project B	Δ for B over A
Material Cost			
Raw material debit	200,000	200,000	—
By-product credit	50,000	80,000	+30,000
Net material cost	150,000	120,000	−30,000
Manufacturing Cost			
Labor, maintenance, utilities	250,000	200,000	−50,000
Overheads	150,000	130,000	−20,000
Depreciation	100,000	120,000	+20,000
Total manufacturing cost	500,000	450,000	−50,000
Total product cost	650,000	570,000	−80,000
Income less marketing expense	850,000	850,000	—
Profit before income tax	200,000	280,000	+80,000
Net profit after income tax @ 50%	100,000	140,000	+40,000
Investment	1,000,000	1,200,000	+200,000
Return	—	—	—

TABLE 3. Pay Out Method Project "A."

$$\text{Pay out time – years} = \frac{\text{Investment}}{\text{Yearly profit and depreciation}}$$

$$= \frac{\$1{,}000{,}000}{\$200{,}000 + \$100{,}000}$$

$$\text{Pay out time – years} = 3.3$$

for the earnings from the project to equal the original investment.

For project "A" payout time is represented by the $1 million dollar investment, divided by the $200,000 per year profit plus the $100,000 per year depreciation — giving a 3.3 year payout (Table 3). The shortcomings of the pay out method are well known — inability to reflect the earning pattern after the investment is returned, inability to properly reflect irregularities in income and expense patterns and no indication of the projects ultimate earnings. Actually the expected life of most projects can usually be approximated and thus pay out time while neither sensitive enough nor inclusive enough serves as a simple, rough, but readily understood reference of project profitability.

Operators' method

The return on investment by the operators' method may be defined as the ratio of the annual cash return or profit before depreciation to the original investment.

TABLE 4. Operators' Method Project "A."

$$\text{Return on Investment} = \frac{\text{Annual profit and depreciation}}{\text{Investment}}$$

$$= \frac{\$200{,}000 + \$100{,}000}{\$1{,}000{,}000}$$

$$\text{Return on Investment} = 30\%$$

JOHN C. MARTIN, director of the administrative section, research and development department, The Atlantic Refining Company, has been concerned for a number of years with process and product economic analysis, the development of refining process standards, and crude oil evaluation activities. He now directs the economic evaluation activities of the research and development department as well as the technical information center, studies in statistics and optimization, and other administrative activities. Martin, who holds a BS in chemical engineering, is a member of the American Chemical Society, American Institute of Chemical Engineers, the Franklin Institute, and the Engineers' Club of Philadelphia.

TABLE 5. The Accounting Method — Project A.

Year	Profit before Depreciation	Depreciation	Profit after Depreciation	Average Outstanding Investment
1	$300,000	$100,000	$200,000	$950,000
2	300,000	100,000	200,000	850,090
3	300,000	100,000	200,000	750,000
4	300,000	100,000	200,000	650,000
5	300,000	100,000	200,000	550,000
10	300,000	100,000	200,000	50,000
Total	$3,000,000	$1,000,000	$2,000,000	$5,000,000

$$\text{Rate of return} = \frac{\text{Total profit after depreciation}}{\text{Total annual outstanding investment}}$$

$$= \frac{\$2{,}003{,}000}{\$5{,}000{,}000}$$

$$\text{Rate of return} = 40\%$$

For project "A" the rate of return by the Operators' method is the ratio of the profit of $200,000 per year and depreciation, $100,000 per year, to the original investment or 30 percent (Table 4). In other words, 30 percent of the investment is returned each year. This procedure is used primarily in evaluating the operating effectiveness of the managers of divisions or parts of the company. As such, a useful variation is to include all the assets employed in carrying out the operation, if they can be reasonably determined. The denominator would thus become investment cost plus working capital (inventory, supplies, etc.). Most companies maintain their equipment in top condition throughout its operating life. Thus the original investment can be considered a reasonable reference point against which to judge operating profitability and performance. To the extent that age affects operating efficiency through higher maintenance and poorer performance, the return in later years, other things being equal, will be somewhat lower. On the other hand, the use of depreciated values of equipment would show a significant downward trend in operating investment due to growth of reserves and lead to distortion of

TABLE 6. The Accounting Method — Project A.

Year	Profit before Depreciation	Depreciation	Profit after Depreciation	Average Outstanding Investment
1	$300,000	$200,000	$100,000	$900,000
2	300,000	200,000	100,000	700,000
3	300,000	200,000	100,000	500,000
4	300,000	200,000	100,000	300,000
5	300,000	200,000	100,000	100,000
6	300,000	0	300,000	0
10	300,000	0	300,000	0
Total	$3,000,000	$1,000,000	$2,000,000	$2,500,000

$$\text{Rate of return} = \frac{\text{Total profit after depreciation}}{\text{Total annual outstanding investment}}$$

$$= \frac{\$2{,}000{,}000}{\$2{,}500{,}000}$$

$$\text{Rate of return} = 80\%$$

indicated return on investment. It could also lead to delay in replacing old equipment that is no longer efficient since it would appear to be earning a high rate of return. This method, however, is essentially the reciprocal of the payout time and has many of the limitations of the pay out method.

Accounting method

The two previous methods related profit to initial investment or assets employed in earning that profit. The Accounting Method differs in that profit after depreciation is related to average annual outstanding investment. This assumes that capital recovered as depreciation is available for use in other projects and should no longer be considered a charge against the original project. Table 5 illustrates the application of the Accounting Method to Project "A."

Again, annual profit of $300,000 becomes $200,000 per year after depreciation. With depreciation at $100,000 per year the initial investment of $1 million dollars becomes $900,000 at the end of the first year — the average outstanding investment over the first year being then $950,000. Continuing this procedure for the 10 year life of the project we have a total profit of $3,000,000 before total depreciation of $1,000,000 representing recovery of our initial investment. The net profit of $2,000,000 can then be related to the total of the outstanding investment over that same period of time to arrive at a rate of return by the Accounting Method of 40 percent.

Here also variations in procedure are encountered. Return may be calculated on both a before and after tax basis or on an investment based on fixed capital or on fixed plus working capital. Federal income tax considerations are of particular importance in the petroleum industry where different areas of activity will have substantially different tax problems — statutory depletion in the producing phase of the business and both normal and accelerated depreciations in the manufacturing area. It is necessary in any case that the calculations be consistent so that the indicated returns will be directly comparable.

This general procedure has two principal shortcomings. First the calculated return is affected by the selection of the depreciation rate. For example, if the depreciation rate is arbitrarily changed to $200,000 per year for the first 5 years (Table 6), the net profit after taxes is reduced to $100,000 per year in the first 5 years and increases to $300,000 per year in the second 5 years. While total depreciation over the life of the project is constant, it was accumulated faster and the average outstanding investment will now be less and is reflected in a higher rate of return, 80 percent.

We now have a substantially higher indicated rate of return and yet forgetting tax considerations for the moment, the projects are essentially the same, the capital was expended and returned in the same pattern.

The second objection to this method is that it does not reflect the effect on return of the time pattern of capital outlay and income — the time value of money. For example, suppose Project "A," while maintaining the same total income, had the following income pattern.

The only change over the base case is that the profit is $100,000 per year higher in the first 5 years and $100,000 per year lower in the second five years — the total profit over the life of the project remaining at $2,000,000. The average outstanding investment remains the same, $5,000,000, since depreciation rate was constant. Thus, the indicated return is the same 40 percent as the base case.

Yet this project is now certainly a more desirable one since a greater proportion of the total profit is returned earlier in its life. **Failure to reflect the time value of money** in the calculation of rate of return can result in passing up desirable projects or unknowingly entering into low return ventures. Any company that has projects which vary markedly in income pattern, capital outlay schedules or life should use an evaluation procedure that can reflect the effect of such differences.

Investor's method

A common limitation of the methods already discussed has been their inability to properly reflect in the rate of return the time pattern of how the capital was spent and how it was returned. If money is borrowed, interest must be paid; if money is available interest can be obtained.

In borrowing a given sum of money, many different repayment plans can be set up which are equivalent once the interest rate is determined. While the actual dollar repayments are different — the borrower over the life of the loan

TABLE 7. The Accounting Method — Project A.

Year	Profit before Depreciation	Depreciation	Profit after Depreciation	Average Outstanding Investment
1	$400,000	$100,000	$300,000	$950,000
2	400,000	100,000	300,000	850,000
3	400,000	100,000	300,000	750,000
4	400,000	100,000	300,000	650,000
5	400,000	100,000	300,000	550,000
6	200,000	100,000	100,000	450,000
10	200,000	100,000	100,000	50,000
Total	$3,000,000	$1,000,000	$2,000,000	$5,000,000

$$\text{Rate of return} = \frac{\text{Total profit after depreciation}}{\text{Total annual outstanding investment}}$$

$$= \frac{\$2{,}000{,}000}{\$5{,}000{,}000}$$

Rate of return = 40%

TABLE 8. The Investor's Method — Project A.

Investment	$1,000,000
Expenditure period	1 year
Plant life	10 years
Profit and depreciation	$300,000 per year
Salvage value	None

Years from 0 Point	Expenditure or Income	Compound or Discount Rate	Value at 0 point with interest @ 24.2%	
−1 to 0	−1,000,000	1.131	$−1,131,000	
0 to 1	300,000	0.888		$+ 266,000
1 to 2	300,000	0.697		208,000
2 to 3	300,000	0.547		164,000
3 to 4	300,000	0.420		128,000
4 to 5	300,000	0.353		106,000
5 to 10	1,500,000	0.173		259,000
			$−1,131,000	$+1,131,000

will have paid the indicated interest rate and the investor will have received the same interest on his outstanding funds. This interest rate is comparable to the investor's method rate of return.

The investor's method rate of return is the rate of return on invested capital with continuous compounding. Saying it another way, it is the maximum constant rate of interest which a project could pay throughout its life on the outstanding investment and just break even. The essential concept is illustrated in Fig. 1 using Project "A" base case.

On the ordinate are dollars. Time is on the abscissa. All that is required is a timetable of receipts and disbursements of cash, and interest tables. The feature of continuous compounding is not essential, but it does have some advantages of greater flexibility in using a special interest table which facilitates the practical application of the method. The date of spending the first dollar, or date of starting operations, or any other date can be adopted for the zero date or reference point.

The solid line to the left of the vertical axis represents the uniform expenditure over a one year period of the $1 million investment in facilities. The zero date or reference point represents the start of operations. The ascending solid line to the right represents the accumulation of $300,000 per year profit before depreciation. The investment is recovered in 3.3 years equivalent to the pay out time, and at the end of 10 years we have $2,000,000 net cash profit. This represents our position with a zero rate of interest. The problem then becomes one of determining at what maximum rate of interest money could be borrowed for this project without ending up in the red. By a cut and try procedure, we arrive at 24.2 percent. The 24.2 percent return indicated for this project means that every dollar of outstanding investment from the time the first dollar is spent until the project is closed out effectively is earning 24.2 percent with continuous compounding. Any changes in the magnitude or timing of either capital outlay or income will be reflected in the calculated rate of return.

A dollar today is worth more than the prospect of a dollar next year or 10 years from now. Thus another way of expressing this method is: The interest rate that discounts all future earnings of the project down to a present value just equal to the investment compounded at the same rate to the same point in time. This is the technique most frequently used in practice. Table 8 summarizes a timetable of expenditure and income for Project A, in which the $1 million dollar capital expenditure for plant is spent over a one year period prior to initial operation and the $300,000 per year income is accumulated over the succeeding 10 year period. By trial we find that by discounting the $300,000 returned each year at a rate of 24.2 percent, the present worth of the yearly income in each of the years (column on the right) just equals in total ($1,131,000) the capital outlay compounded at the equivalent rate to the same point ($1,131,000).

While the investor's method gives the impression of mathematical complexity, it is actually quite simple in application and the technique is readily grasped after a few trials by the many people in an organization who have occasion to use the various evaluation procedures.

Project profitability is not only concerned with the ratio of the dollars returned to the dollars invested, but is also concerned with when these dollars were spent and when they were returned.

Project present worth

The time value of money depends on the earning rate at which money is reinvested. If the income from a project is not going to be reinvested, or is invested in projects which show no return, then there is no advantage in obtaining the money early in the project life. If it is going to be reinvested at a high earning rate, it is, of course, desirable to get it as soon as possible. An alternative interest approach to project desirability is to establish independently the reference interest rate, and then solve for the present worth of the project under consideration.

If, for example, it is assumed that there are essentially limitless opportunities to invest at, say 20 percent, and that the receipts of whatever project is under consideration will be reinvested at 20 percent, the project evaluation becomes a comparison of the company profit investing money in a given project to profit which would result were the money invested in 20 percent projects.

As illustrated in Table 9, the project present worth of Project "A" at 20 percent interest rate would be $190,000. This states, in effect, that you are $190,000 better off by investing in this project rather than any other available 20 percent project. The problem involved in this variation in accounting for the time value of money is first, the difficulty in forecasting the cost of capital. It changes with the condition of the money markets and the economic attractiveness of the company's marginal projects. In addition, most

TABLE 9. Present Worth Method — Project A.

Years from 0 point	Expenditure or Income	Compound or Discount Rate	Value at 0 point with Interest @ 20%	
−1 to 0	−1,000,000	1.107	$−1,107,000	
0 to 1	300,000	.906		$+272,000
1 to 2	300,000	.742		222,000
2 to 3	300,000	.608		182,000
3 to 4	300,000	.497		149,000
4 to 5	300,000	.407		122,000
5 to 10	1,500,000	.233		350,000
			$−1,107,000	$+1,297,000
		Present worth		$+190,000

TABLE 10. Comparison of Indices of Return — Project A.

Investment $1,000,000
Plant life ..... 10 years
Profit ..... $300,000 per year (before depreciation)

Basis	Pay Out Method Yr	Operator's Method %	Accounting Method %	Investor's Method %	Present worth @ 20% interest $
1. 1-yr construction time profit uniform	3.3	30	40	24.2	190,000
2. 2-yr construction time profit uniform	3.3	30	40	21.1	67,000
3. 1-yr construction accelerated deprec.	3.3	30	80	24.2	190,000
4. 1-yr construction time accelerated profit	2.5	30	40	29.6	391,000
5. 1-yr construction time 50% residual value	3.3	35	33	25.2	258,000

Caustic Slash-Water Wash Electrofining

Licensed by: Petrolite Corporation

DESCRIPTION: This process employs the use of caustic soda, in concentrations of 40 to 45 percent by weight, to solutize and react undesirable organic compounds from cracked hydrocarbon fractions. The resolution and/or coalescence of the spent caustic emulsion is effected by the action of a high d-c voltage electrical field in a Petreco Electrofiner*.

The effluent oil from the caustic Electrofining* stage will contain soluble organic soaps and trace quantities of insoluble soaps. By contacting this stream with water through a mixing device and again subjecting the emulsion to the action of a second Electrofiner stage, the trace impurities are removed. The effluent oil from the water wash stage will contain less than one (1) ppm trace metal ions (ca, mg and na).

The stream rates handled by the Electrofining units vary from 500 to 30,000 bbl per day. The caustic used may be either fresh or recycle caustic.

In the water wash stage either once-through fresh water is used, or recycle water with constant make-up and withdrawal is employed. Economics and water availability dictate the mode of operation. In either case the quantities of impurities contained in the effluent water are of such minor significance that pollution is not effected.

CHEMICALS:
Caustic Strength 40 to 45% by weight.
Dosage Rates ..0.05 to 0.5 lb/bbl.

WATER:
Source .....Clarified, low hardness water.
Rate .....5 to 10% by volume, oil basis.

IMPURITIES REMOVED:
Mercaptans, tarry acids, trace metals, and catalyst fines.

OPERATING MANPOWER:
Approximately one hr. per 8 hr. shift.

TREATING COSTS:
Caustic .....0.15 to 1.5 cents/bbl.
water .....0.004 cents/bbl max.
Electricity .....0.01 cents/bbl
Labor .....0.1 to 0.5 cents/bbl max.

INSTALLATION COSTS:
$10 to $15 per bbl

ADVANTAGES:
1. Minimizes polution problems.
2. Automatic, continuous
3. No product loss.
4. Maximum efficiency obtained from chemical used.
5. Minor operational supervision.
6. Uniform products.
7. Low real estate requirements.
8. Negligible maintenance.

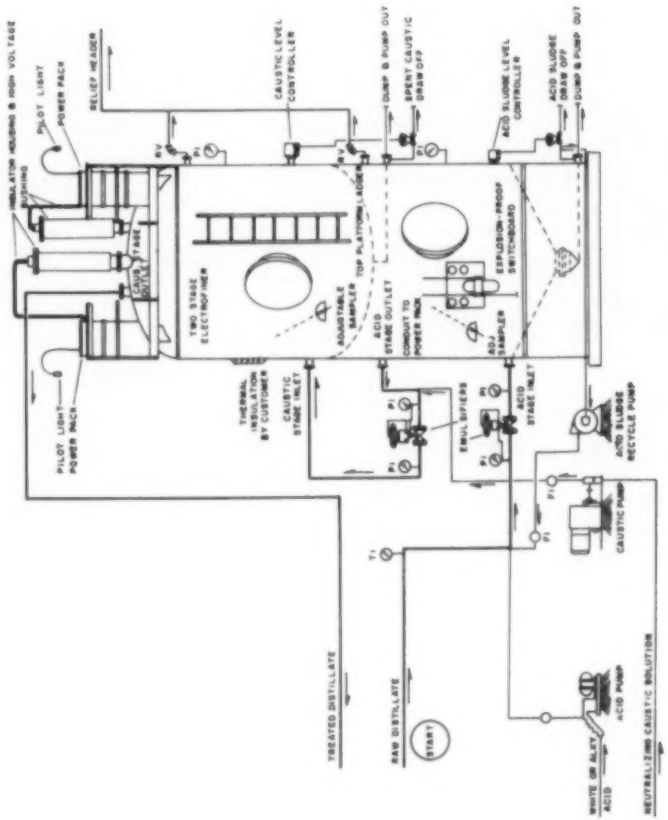
*Registered Trademarks of Petrolite Corporation

PETRECO ELECTROFINERS
Strong Caustic-Water Wash
OPERATING DATA

Plant Location	Type Stream	Rate Charge bbl per day	Vessel Size	Reason for Treat	Results Obtained	Treating Temperature ° F.	Caustic Rate lb/bbl	Caustic Strength %/Wgt.	Water Rate %/Vol.	Trace metals ppm
1. Pennsylvania	Hvy. Cat. Gasoline	3600	6'-6"	Remove Organic Acid, RSH, Olefins	Reduced Gums, Sweetened Stream	100° to 115° F.	0.5	40	5.0	less than 1.0
2. Pennsylvania	Hvy. Cat. Gasoline	12500	10'	Remove Organic Acid, RSH, Olefins	Reduced Gums, Sweetened Stream	100° to 115° F.	0.5	40	5.0	less than 1.0
3. Texas	Lt. Cat. Cycle	6000	10'	Remove Tarry Acids, Reduce RSH, Stabilize Color	Color Stability Low Trace Metals	120° to 130° F.	0.3	42	10.0	0.5
4. Texas	Thermal #2 Fuel	5000	10'	Improve Odor, Stabilize Color	Color Stability Improve Odor	120° to 130° F.	0.25	42	10.0	0.8
5. Texas	Lt. Cat. Cycle	15000	12"	Remove Sediment, Stabilize Color	Color Stability Low Sed. Low Trace Metals	120° to 130° F.	0.25	42	10.0	0.6
6. Arkansas	Coker Naphtha	1800	8'	Stabilize Color, Reduce Sed.	Stabilize Color, Reduce Sed.	130° F.	0.25	42	10.0	1.0

Acid-Alkali Electrofining

Licensed by: Petrolite Corporation



Acid - Alkali Electrofining

Licensed by: Petrolite Corporation

DESCRIPTION: The Electrofining* process for removing impurities from both virgin and cracked distillates is essentially a combination of chemical and electrical methods. Precise control of the acid and caustic soda give the degree of purification required to satisfy the particular stream specifications. The high voltage electrostatic field removes the acid, caustic, and reaction products from the oil as it progresses through the system.

The 2-stage electrofiner may be two separate precipitating vessels or a single vessel divided into two compartments as illustrated. The latter arrangement has the advantage of using less real estate, piping, and platforms.

Oil and acid are intimately mixed by some mechanical means, usually an emulsifying valve, and the resultant mixture subjected to a high voltage - low current field. The acid sludge bearing the impurities is removed from the oil and is withdrawn from the bottom of the precipitator. The acidulous oil, containing only trace quantities (less than 0.005 percent by volume) of entrained acid sludge then flows to the caustic mixing stage where a fixed amount of alkali is added, based on the acid content of the oil, and intimately mixed. The neutral emulsion then flows to the caustic precipitator where the reaction products and spent caustic are separated from the oil. The clean neutral oil then flows to either storage or further refining. The spent aqueous phase is withdrawn continuously. The caustic may be used on a once-through basis or recycled with fixed make-up rates for a given stream rate.

Stream rates being handled by Petreco* in acid-alkali Electrofiners vary from 500 to 40,000 bbl per day.

CHEMICALS:

1. Acid ..... H_2SO_4, either spent alky., 93%, 98%, or fuming.
   Dosages ..... 0.5 to 40 lb/bbl.
2. Caustic ..... 2° to 25° Be'
   Dosages ..... Equivalent to neutralize oil.

IMPURITIES REMOVED:

Nitrogen bases, arsenic, lead, sulfur, mercaptan sulfur, vanadium, nickel, gums, and olefins.

OPERATING MANPOWER:

Approximately one hr. per 8-hr. shift.

OPERATING COSTS:

Acid	0.1 to 40 cents/bbl
Caustic	0.05 to 3.0 cents/bbl
Electricity	0.01cents/bbl
Labor	0.5 cents/bbl average

INSTALLATION COSTS:

$10 to $15 per bbl

*Registered Trademarks of Petrolite Corporation

PETRECO ELECTROFINERS

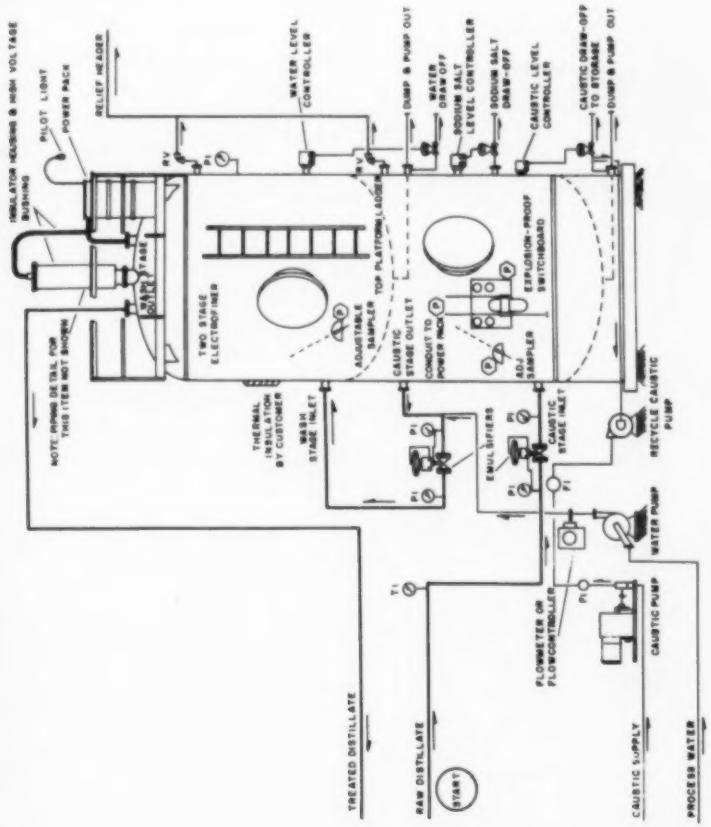
Acid-Alkali Treat

OPERATING DATA

Plant Location	Type Stream	Charge Rate BPD	Vessel Size	Reason for Treat	Results Obtained	Treating Temperature	Acid Dosage lb/bbl	Acid Strength	Caustic Strength	Caustic Consumption lb/bbl
1. Oklahoma	Platform Feed	6000	10'	Remove Arsenic, Lead, Sulfur	Arsenic less than 5 ppb.Sulfur removal 60%	100° F.	0.5	Spent Alky	0.5° Be'	0.02
2. Texas	Platform Feed	6000	10'	Remove Sulfur, Arsenic	Arsenic less than 1 ppb.Sulfur removal 74%	100° F.	2.0	Spent Alky	2.0° Be'	0.25
3. California	Jet Fuel	3500	6' - 6"	Remove Sulfur, Gums	Pass Water Tolerance Test	110° F.	2.0	Spent Alky	7.0° Be'	0.5
4. California	Jet Fuel	6000	8'	Remove Sulfur, Gums	Pass Water Tolerance Test	110° F.	2.0	Spent Alky	7.0° Be'	0.5
5. Indiana	Spray Oil	2300	6' - 6"	Improve Odor, Color	Good Color Good Odor	125° F.	40.0	105%	25.0° Be'	3.0
6. Illinois	Coker Naphtha	1800	2 - 42"	Remove Arsenic Nitrogen bases	Remove 95% N_2, Arsenic Removed	105° F.	0.5	Spent Alky	0.5° Be'	0.02

Caustic Slash-Water Wash Electrofining

Licensed by: Petrolite Corporation



companies have more desirable projects than can be handled at any one time so that in effect money is limited by management decision for one reason or another. Thus we want to promote those projects with high indicated rates of return rather than those with large "present worths" which may be so mainly as a result of their size. It is also more convenient to handle some kind of index number rather than a number of dollars.

The various methods of indicating the economic desirability of Project "A" can now be compared with one another and the effect of variations in income and outlay illustrated.

Item 1 in Table 10 summarizes the base case and indicates a pay out time of 3.3 years, a return of 30 percent by the operator's method which relates profit to original investment, a 40 percent return by the accounting method which relates profit after depreciation to the average outstanding investment, 24.2 percent by the investor's method, and a project present worth of $190,000.

Suppose, however, it takes two years to install the facilities and initiate operation rather than one year. This is obviously not as desirable a situation, since the company's capital is tied up for a longer period of time. However, as indicated by item 2, the return indicated by the pay out time, the operator's method and the accounting method have not changed. The return is less by the investor's method, (21.1 percent) and the project present worth is less — now $67,000.

Item 3 illustrates the effect of change in depreciation rate, excluding again the tax considerations. If depreciation rate is accelerated, as in Table 6, pay out time and the operator's method return remain unchanged. Since the return by the accounting method is directly related to the average outstanding investment, which is now lower, it is significantly better, (80 percent). The investor's method indicated rate of return and the present worth remain the same since the dollars were expanded and returned in the same pattern.

In item 4, it is assumed that more of the profit is returned in the early life of this project (as in Table 7). If today's dollar is worth more than the prospect of a future dollar, this should be a more desirable alternate. The pay out method correctly indicates the direction of change in that it now takes only 2.5 years to recover the investment. The operator's method might or might not reflect a change in desirability depending upon whether we look at a specific year or the average over the life of the project. The accounting method shows no change from the base situation, since it is fundamentally not concerned with when the money is returned. Both the investor's method and present worth reflect a more economically desirable project.

Item 5 in Table 10 illustrates the effect on the returns of a high residual value at the close of the project's life. Since pay out time is not concerned with return of dollars beyond the point of recovery of original investment, it is again 3.3 years. The operator's method shows this to be somewhat more advantageous over the life of the project. The accounting method, however, can give an erroneous indication of change in desirability since the average outstanding investment over the life of the project is higher. Both the investor's method return and the present worth are rightly somewhat higher by virtue of additional return of dollars 10 years from now.

The first three methods have the advantage of being familiar and understandable to those who must make the final decisions. They are frequently used either by themselves or in conjunction with another procedure as a check. Those procedures incorporating the interest factor weigh the time pattern of investment and return so that real and important differences are properly reflected in the investment worth of a project.

TABLE 11. Comparison of Total Company Return Expanding vs Non-Expanding Company (Thousands of Dollars).

Year	Company Not Expanding All Net Profit to Stockholders	Company Expanding 65% of Net Profit Reinvested Each Year				
		1	2	5	10	15
Gross Plant	10,000[1]	10,565	11,212	13,767	21,131	32,064
Net Plant 12/31[2]	5,500	6,065	6,655	8,614	12,817	19,190
Working Capital 12/31[3]	1,500	1,585	1,682	2,068	3,175	4,816
Net Worth 12/31[4]	7,000	7,650	8,337	10,682	15,992	24,006
Net Worth 6/31	7,000	7,325	7,994	10.265	15,367	23,071
Net Profit before deprec. and taxes[5]	3,000	3,000	3,170	3,840	5,770	8,610
Depreciation—10%/yr	1,000	1,000	1,057	1,280	1,924	2,870
Net Profit before income taxes	2,000	2,000	2,113	2,560	3,846	5,740
Net Profit after 50% income taxes	1,000	1,000	1,054	1,280	1,920	2,870
Net Profit % of Net Worth 6/31	14.3	13.7	13.2	12.5	12.5	12.5
Average Age of Gross plant yr	5.0	4.8	4.6	4.4	4.5	4.5

[1]Ten $1-million projects each with 10-year life. One replacement constructed each year with depreciation reserves.

[2]Net Plant based on straight line depreciation, one year construction time and ten year life.

[3]Working capital assumed as 15 percent of gross plant.

[4]Net worth equal to net plant plus working capital.

[5]All money invested in $300,000 per year profit projects (before depreciation and taxes).

Project evaluation

There are two aspects of the project evaluation problem. One is the determination of the profitability of the proposed venture and the other is the financial yardstick against which it should be judged.

How does a given rate of return from project evaluation relate to the company cost of capital or the company rate of return, measured as say, percent return on employed capital or net worth, and calculated from the income statement and balance sheet?

First, the problem can be avoided by arranging projects in a "ladder" of priority with the highest return projects at the top, the cut-off point being determined by the exhaustion of available funds. Such a list will usually be found to include urgent projects which may have poorly defined returns, and company policy or status projects, all of which may be eloquently and persistently presented. The net result is that management does not know whether the sum total of proposed investments enhances or downgrades the return on the enterprise as a whole.

Another alternate yardstick would be the company's cost of obtaining new capital. Using some combination of additional long term debt and new common stock, we might arrive at an average of say 8 percent. The rate of return for any given project can then be compared to this cost

of capital to determine whether it is economically justified. This reference point for the cost of additional capital may differ significantly from the company's existing rate of return on employed capital as indicated from the balance sheet. If this is the case, this reference point is of primary value only if a company's internally generated funds are insufficient or not available for the future capital program.

Since most companies finance new investment opportunities primarily from internally generated funds, a benchmark developed from this basis achieves some significance. The company rate of return determined from the relation of annual profit to net worth or the total value of the business (total assets less current liabilities) can be considered a measure of management efficiency. This being the case, management desires to know how the profitability of any proposed project will affect the company rate of return.

What would company return be, calculated from the financial statements, if we invested exclusively in Project "A" projects? In such a dynamic situation, what factors modify return rate?

Table 11 depicts such a situation. Here we have ten $1 million projects, each with a ten year life — one replacement being constructed each year with depreciation reserves. This results in 10 plants operating and one plant under construction. This means that the average investment is outstanding for 11 years on the company's balance sheet while the project is earning for only ten years. Increasing construction time then has an adverse affect on company return.

A review of past history reveals that our hypothetical company has required working capital (current assets minus current liabilities) equivalent to about 15 percent of the investment in new projects. Working capital is thus additive to net plant in determining rate of company return and high working capital requirements lower company return.

Depreciation theoretically is the money set aside from earnings so that a plant can be replaced. Actually, in a large diversified company, the earnings from current operations which are set aside for depreciation reserves may be used as a source of capital for new projects. In this manner, it is possible to maintain a plant which has an original value almost twice the depreciated value.

Another factor affecting company rate of return is the fact that in an expanding company a higher percentage of the earning projects are earlier in their lives than in a company which is not expanding. If, for example, our hypothetical company invests in projects having a 10-year life and pays all earnings to the stockholders and does not expand, it will indicate an average gross plant age of 5.0 years (Table 11). However, if the company starts to expand and continues expanding by reinvesting 65 percent of net earnings after taxes in the business, the average age of the plant decreases to about 4.5 years. This has the effect of decreasing the total company rate of return, since the investment in plant at an average age of 4.5 years is about 10 percent higher than at 5 years of age, assuming again straight line depreciation and a 10-year life. Yearly net profit, however, increases substantially. This is illustrative of the significant effect on a company's growth of judicious project selection coupled with the use of internally generated funds.

Income taxes at 50 percent, of course, reduce the rate of return directly.

Under the above circumstances, we see that investing exclusively in Project "A" type projects, our hypothetical expanding company would indicate a 12.5 percent return on net worth, Table 11 (total assets less current liabilities). This compares with a rate of return on individual projects by the investors method, after including working capital and the effect of income tax, of 12.0 percent. Year to year variations in the company rate of return will occur, if the ratio of working capital to investment fluctuates from the long term average, by the sale of plant, and by any increase in long term debt. These are generally small in effect on the longer term average. Due principally to the fact that compounding does not occur in the company's operations, the calculated return by the investors method which properly differentiates between individual projects will differ somewhat from the average contribution of this project to the total company return as determined from the income statement and balance sheet. It does, however, give reasonably close agreement over the usual range of company profitability, as noted below.

10-Year Life Projects

Project rate of return by the Investor's Method (including working capital + income tax)	Related total company return (from annual income statement and balance sheet)
5.2	5.0
12.0	12.5
13.3	15.0

The relationship can be calculated specifically for other situations covering different rates of company reinvestment, project life, construction time, depreciation rates, etc.

Project evaluation can be no more accurate than the basic data. The best forecasts of prices, volumes, and times are necessary for sound conclusions. Imagination as well as technical knowledge is required in order that all pertinent alternatives be recognized, evaluated and related to company return. Regardless of which index of project return is used, it cannot be a "crystal ball" and the exercise of judgment with respect to market trends, availability of capital, risk factors, and technological features is still necessary before deciding on a given project.

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DISCUSSION INVITED . . . the authors of papers appreciate comments and discussion from the readers. Please address your replies . . . for publication or to be directed to the authors . . . to **J. C. Webb, Editor, P. O. Box 1589, Dallas 21, Texas.**

consider these factors affecting plant costs

RALPH W. CLARK

MEET THE AUTHOR

RALPH W. CLARK is a senior project engineer in the New York Engineering office of U. S. Industrial Chemicals Company, a division of National Distillers and Chemical Corporation. He was educated in Mechanical Engineering and has spent many years in the petroleum, petrochemical and contracting field in design, engineering construction and cost estimating work. He is a registered professional engineer in Massachusetts and a member of the American Association of Cost Engineers.

THERE WAS A TIME when a cost estimate was just a compilation of numbers put together to present a dollar cost for some new venture. The people who put the material together were not particularly interested in the costs. Today, with all the problems facing business, management must be provided with accurate, reliable cost information to make decisions concerning new products, new plants, new locations and, incidently, a new product called *profit*.

The cost engineer must, therefore, have reliable cost data. He must combine experience and good judgment in using the cost data that is available. He must stay abreast of current cost information by communicating or by association with other people in his field of interest. He must be well informed in all the many phases of his particular company, its policies, and the politics of its organization. All of the factors that affect the result of his work must be presented, be brought out in the open. Responsible people must understand that these factors do exist, that they affect the economics of the company. The cost engineer, as much as any single person in the company, is responsible for the economic growth of the company.

Plant Location

This is probably the most important single factor affecting costs facing us and one we can do the least about. It imposes additional cost on every plant activity throughout the life time of the plant.

Let us look at two typical situations that would highlight the many problems that might be encountered and how they would affect the costs in each situation. These two situations are extremes. However, any location would have similar problems.

We will first look at a more or less desirable site. We will locate our plant in a heavily industrialized area, close to both railroad and water transportation. We will have at our disposal a large labor pool of trained and experienced personnel. The laws, regulations and controls concerning buildings, zoning, pollution, etc., will be well defined and enforced. The local community would be accustomed to industry.

In the above situation we would find that land values would be high; also that land would be scarce so we might have less area to build on, and less possibility for future expansion. The site being near the water, we would expect soil conditions to be poor. All heavy loads would have to be supported on piling or more elaborate spread footings. The effect would be felt in underground sewers, piping, and electrical services; also in roads and in the disposal of surface water. Labor, while it would be plentiful and well trained, would be well organized and demanding. The working rules would spell out what crafts would be employed, the fringe benefits, ratio of foremen to laborers, hours of work and all the other demands. In a heavily industrialized area many other problems face the company, such as the necessity for added corrosion protection, added fire protection, some mutual plan with other companies in

the area for disaster relief. The laws, regulations, and controls that govern buildings, zoning, pollution, and other company activities are well defined, but do impose additional first costs and continuing costs for maintenance and inspection during the duration of the plant. The local community would be more tolerant of industry since they would have been accustomed to their presences. They would recognize the contributions that industry makes to the community life.

Now we will look at the second situation. We will locate our plant in a remote spot, away from other major industries. We will locate on the main line of a railroad. However, we will not have access to a large labor pool. The community in which we locate our plant will not be accustomed to industry and the laws, regulations, and controls will not be established.

In this situation the land value will be fairly reasonable, unless some individuals hold out for a higher price. There would be enough land for present and future use. Soil conditions would be satisfactory or we will assume they are for this case. We will be at a disadvantage from the start insofar as labor is concerned. We have two choices, either to train local people or to bring in all plant personnel. In order to get construction or maintenance personnel we will have to depend on the nearest labor union. Labor will certainly demand concessions to travel to the area and will only be available when other areas nearer their homes have a surplus of manpower. The laws, regulations and controls that govern buildings, zoning, pollution, and other industry activities are not clearly defined or enforced. They may be instituted against the company as the need arises; at such time they tend to be discriminatory. In any event, it is additional cost that may not have been anticipated. New industry in a community is usually at the mercy of local political and pressure groups who continually make demands of the company. The community as a whole opposes the encroachment of industry into their lives. The company is continually involved in legal matters that is not only time-consuming, but extremely costly.

I doubt if there is such a place as a perfect site; certainly some sites are more desirable than others. When picking a location for plant, consideration must be given to soil conditions, water supply, transportation facilities, electric power source, weather, access to raw material, nearness to market, and a host of other items. The people who are responsible for deciding a plant location must realize that these conditions must be lived with throughout the duration of the plant, and would impose a burden, not only during the initial operation, but as its effect on any expansion, as well as operating, maintenance, safety, sales; in fact, every activity of the company, for the duration of the plant.

Company Philosophy

In every company, large or small, management allocates money for specific uses. They make these allocations at the requests of certain people to expand, improve or maintain their particular responsibility. In appropriating money for specific uses management's desire is to spend as few dollars as necessary to achieve the maximum results. In a small organization this can be controlled quite easily by the boss, who, after all, is spending his own money. In a larger organization there are more people who are involved in various money decisions; so, consequently, more demands must be satisfied. These demands are imposed by process design, mechanical design, operating requirements, maintenance, safety regulations, storage requirements, sales, shipping requirements, and a host of others. While all of these demands may have justifications, they do have a dollar cost and, as a result, they affect the overall cost of doing business.

All companies, large or small, are in business primarily to make a profit. A quick look at some of the published financial reports shows that certain companies consistently show a higher profit than their competitors. When two companies are in the same business, dealing in the same basic products, and are comparable in size, yet one shows consistently a higher return on their investment, there must be some basic reason other than luck.

The explanation must be in the company's overall philosophy. Everyone in the organization is doing everything in his power to keep costs to a minimum, and also to see that value is received for every dollar expended.

Company Specifications

Properly written instructions must be furnished to the supplier or manufacturer in order to secure material and equipment to serve your requirements. Specifications are your specific, written instructions for material and equipment you wish to buy. Specifications should never be so specific, rigid, or inflexible as to restrict the supplier or manufacturer from using his ingenuity, know-how, or competitive position. Your instructions should avoid such cliches as "or equal," "similar to," "good refinery practice," etc. Before specifiying an item which may result in being "tailor made" or " custom built," check with the manufacturer; you may find his product fits your requirements. Manufacturers have certain standards, also have tailored their product to cover definite temperature, pressure and capacity ranges. The cost estimator is obligated to compare and evaluate material and equipment prices. He is in the best position of anyone in the organization to point out additional costs due to rigid specifications.

Many companies pay from 5 to 20 percent extra for material and/or equipment purchased to their own specifications. This doesn't mean to say that they don't get their moneys' worth or that, if the conditions require a rigid specification, that this additional cost isn't justified; just be sure that a standard conventional item would not serve just as well.

Company Standards

It is essential that a company set up certain standards for equipment and/or material. This is to avoid having a wide variety of equipment and material, also to keep maintenance costs at a minimum and to reduce numbers of spare parts in warehouse stock. Specifications and standards are closely allied; strict specifications could result, though, in having all pumps from, say, one manufacturer. The Cost Engineer should never minimize the selection of equipment or material strictly on spare or replacement parts. Many manufacturers now provide interchangeability of parts in their equipment. The pant may want to have some variety so as not to place the company in a position of being dependent on one or two sources of supply.

Most companies do try and standardize on such items as Heat Exchanger tubes; these standards are in tube diameter, gauge and tube length. There is usually minimum and maximum overall size and weight of the Heat Exchange unit. There are also certain minimum size for underground piping. These standards are also considered in instrument piping, wire size, conduit sizes, etc. The standards should never be so rigid as to eliminate the purchase of a new and improved design of equipment, or the use of new and improved material of any category. Consideration should

always be given to any equipment and/or material that is less expensive than what is being used today.

Process Design

Process engineers follow certain prescribed design concepts in their work. The design data is not always complete and exact, and, too, there is some extra capacity designed in most process. The Process Engineer, due to his knowledge of the chemicals and process streams he is using in his design, usually recommends the material of construction for the equipment items, piping system, etc. The Process Engineer should, when design conditions make it necessary, point out the use of any special or exotic materials of construction; he should also point out any unusual temperatures, pressures or capacities, especially when these are higher than the usual practice.

The Cost Engineer is in a position to evaluate the Process Engineer's recommendations. He may be able to suggest changes in the original process design that may not have been considered; it is possible that the temperature, pressure or capacity might be altered some to fit a company or manufacturer standard better. Changes in the process design may affect savings in the foundation, structural steel, piping, instrumentation, insulation, electrical or other phases of the project. The Cost Engineer should point out the additional cost to the project of any excess capacity, over design or other items that may or may not be required.

Mechanical Design

Mechanical design must follow certain codes, such as for pressure vessels and piping. There is a basic design concept for foundations, structures, buildings, etc. To a degree, these concepts or design criteria dictate or limit the Design Engineer in his work.

The Cost Engineer may, by his experience, be able to assist the Design Engineer in the achievement of a design that is both economical and satisfactory. There should be a concerted effort on the part of the designer and the Cost Engineer to explore the use of new materials, new alloys, improved design in equipment; they should also explore new methods of construction, new and improved equipment and methods for handling equipment and material. Examine and evaluate any and all of the modern advancement for cost savings. Do not hesitate to take advantage of these new developments if you find they serve your purpose.

Material, equipment, and products are made to precise standards, better quality, more controls used in their manufacture, designed to tighter specifications than in former years. The modern equipment is extremely dependable and they should recognize this dependability.

Attitude Toward Salesmen

We all have had occasion, at one time or another, to obtain information, prices, drawings, etc., from suppliers or manufacturers. This information is obtained through the assistance of the local sales representative. The individual is usually limited in time and energy in doing his work and would appreciate your consideration in helping him use his time effectively. Don't keep him waiting if he calls on you. Don't ask him to do something you should do. Help him get credit for the work he has helped you with. On the other hand, don't let him waste your time. Always remember that he is ready, willing and able to give you assistance on your particular problems. While you may have some knowledge and experience on the particular problem, his organization may have been through this same problem before; in fact, may have a satisfactory solution to the problem, and one you might not otherwise have reached.

Labor Unions

The cost engineer may never have an opportunity to sit on labor negotiations, or to work directly with union representatives. He should, however, keep informed on the labor-management agreements.

The working rules will be well defined in the union by-laws. They will give the normal working day, rules on overtime, fringe benefits, and so forth. What may be more important to the cost engineer is such items as the following:

1. Will the union be able to furnish enough men for the work in question?
2. Will you be able to bring in men from outside the area?
3. Will pre-fabricated material or equipment furnished to the job site violate the union agreement?

Engineering and Contract Firms

The contracting business is a highly specialized field and, while the approach to a project is quite similar, each firm has its own way of doing business. Some firms conduct their business more efficiently and will do a better job on some work than their competitors; also they may have more experience on certain types of projects. The cost engineer should understand, compare, and evaluate any noticeable difference that he finds exists between firms. When a contract is signed with a specific firm it actually becomes a part of the company organization for the duration of their contract. It is, therefore, important to be sure the firm is the best one on the project.

There are several types of contracts that might be negotiated with an engineering firm. They, basically, fall in either an incentive or non-incentive type of contract. This is an important cost factor and one that should be considered quite carefully.

The so-called cost plus or fixed fee is a non-incentive type of contract, where the fee is a fixed amount, with all other costs to be paid by the owner. This type of contract is entered into when the scope of work is indefinite, or when the design and construction work must be carried out simultaneously. The contractor is inclined to accept conditions; in fact, he has little choice except to do the work he is asked to do, which he would not tolerate if he was working under a lump sum contract. His attitude is often reflected in the field work. The result is that the costs are usually much higher.

The firm price or lump sum type or contract furnishes an incentive to the contractor. It allows him to take full advantage of any efficiencies, also to make full use of his know-how, and to maximize his efforts. This type of contract works best when the scope of work is well defined. Properly conducted, it should result in lower costs.

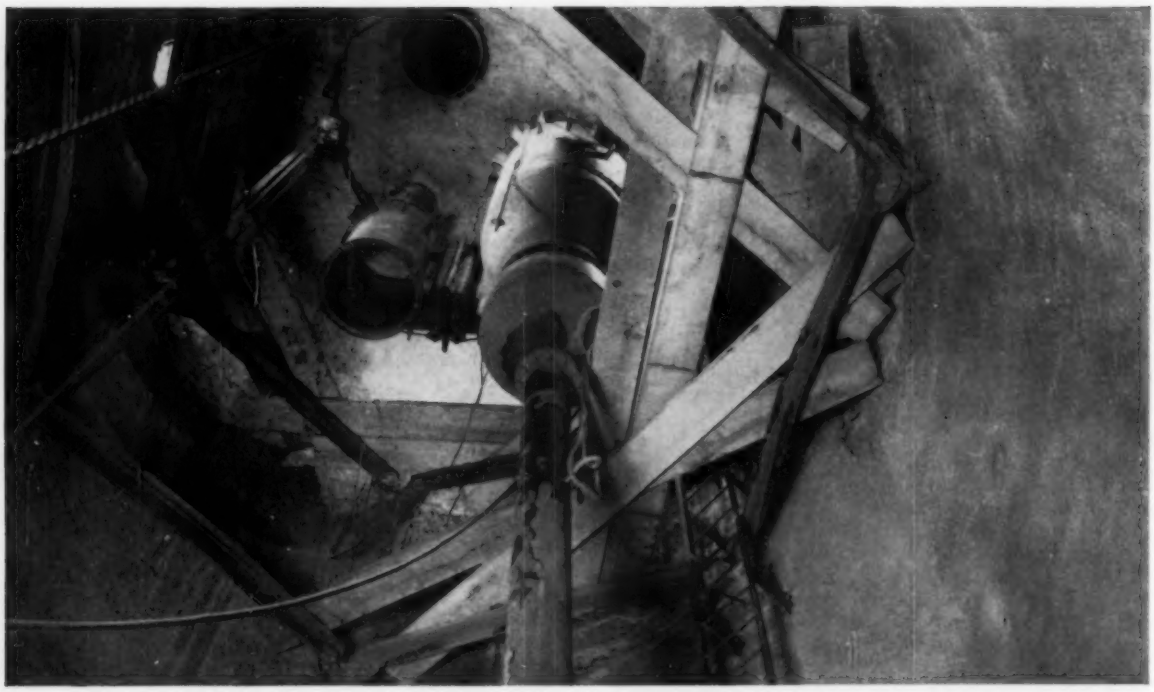
A reputable contractor will perform his functions in the same conscientious manner, working under either type of contract. Everyone needs some incentive to perform at his best. The contractor is no exception.

Other Company Interests

Every company is made up of a number of departments whose responsibilities will, in some way or another, affect the overall costs. The cost engineer should be familiar with these various departments and the extent of each of their responsibilities. Consult with these people for their recommendations, suggestions or requirements, for it is easier to include them in your plans than it is to add them at a later date. In a small organization these may not be full departmental problems, but they will be present in any organization. ★ ★ ★

Five years later:

No repairs needed on regenerator's refractory concrete lining



When this regenerator chamber was opened at the Canton (Ohio) refinery of the Ashland Oil & Refining Company after five years of service, the refractory concrete lining was in excellent condition. No replacement was needed. The smooth, jointless surface of the concrete, made with LUMNITE calcium-aluminate cement, required only minor patching. It resisted abrasion by catalyst and the penetration of gases.

In other refinery equipment (heaters, vapor separators, transfer lines, cyclones, stacks, breechings, etc.) refractory concretes made with LUMNITE cement can be designed to meet every operating condition. For extra convenience and economy, castables containing LUMNITE cement are available from leading manufacturers of refractories. These are packaged mixtures, requiring just water and mixing. For more information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N. Y.

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How to obtain speed and accuracy in preliminary appraisals

E. A. SCHRAISHUHN
Supervisor, Research Planning Staff
Socony Mobil Oil Company
Paulsboro, New Jersey

JOHN KELLETT
Senior Technologist
Socony Mobil Oil Company
Paulsboro, New Jersey

TODAY'S PETRO/CHEM ENGINEER must be able to move fast if he is to exploit profitable opportunities for capital investment. He must have trained personnel to do preliminary process planning. His engineers must learn to appraise all the aspects of a proposed process. They must do this accurately and quickly if their company is to move forward and stay competitive in this fast moving industry.

Preliminary economic appraisal of research and development projects is one of the important steps in the development of a new investment opportunity. Here in the early stages, the lot is cast for the proposed project—the decision is made to start engineering development or to abandon the idea. A successful project must have more than an accurate investment estimate. The process and its products must be integrated with the company's existing markets and production facilities before an accurate appraisal can be made. Errors in the evaluation are usually due to omission of important capital and expense items rather than inaccuracies in the estimates. The following discussion presents a technique used by the authors to improve both speed and accuracy in preliminary evaluations. Checklists have been developed to insure that all important factors in the total cash outlay and manufacturing expense are included.

First estimate total cash outlay

Many papers have been presented on estimating capital requirements for new processes. However, experience shows that process investment is only a part of the total cash outlay required. For example, if a new Petro/Chem plant is to be constructed, the process investment may only be **35-50 percent of the total funds required.** If a new process is added at a fully developed site, the process investment is a larger percentage of the total cash outlay and may be as high as 75-90 percent. Table

1 shows some of the major items that should be checked when considering either a new process or a completely new refinery. The list shows five major categories. These five areas include all the capital and expense items required to initiate the project. The total cash outlay also alerts management regarding the total cash flows needed before profitable production can be realized.

Onsite capital requirements

Process investments usually command the major effort in evaluations because the engineer is naturally more interested in this area. In addition, more complete information is usually available for the battery limits process. However, this may consume valuable time and other important phases of the appraisal may be neglected. Probably the fastest method of estimating process investments is to count the arrowheads on a process flowsheet and multiply this sum by $10,000 . . . unfortunately, this is also the least accurate. In order to make an accurate and fast estimate for new processes, the engineer must be prepared. One way to do this is to continually review the technical literature and make notes on various processes as they are presented or announced. Company experience with past projects has proved to be the best source of information on standard-type units. **These two types of cost data can usually be tabulated in a one-page summary or "thumbnail sketch" for each process.** Moreover, the thumbnail sketch can include more than mere investment data — it can include complete data for operating requirements as well. The Process Notebook of the *Petro/Chem Engineer* has made available summaries of refining and petrochemical processes which are extremely useful for preliminary estimates. These can be used per se or modified slightly to the form used by the authors and shown in Fig. 1 as an example. Summarized there are the complete data required for making estimates on simple gasoline splitters. Note that the data are based on several capacities and overhead fractions. In addition, the bases for the data are clearly recorded in regard to date, cost index, degree of separation, labor and utility requirements, reflux ratio and estimated maintenance and service factors. These types of data make it possible to estimate gasoline splitters with a minimum amount of effort. Our process handbook of thumbnail sketches currently includes more than fifty commercial processes. Each time an order-of-magnitude estimate is made by a member of the staff, he makes a summary for inclusion in the process data book.

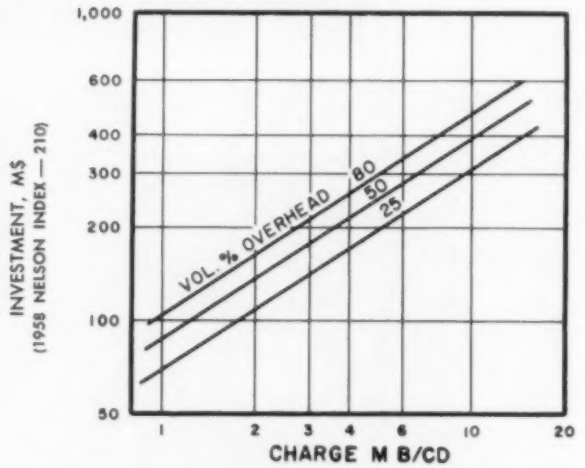
But how do these data help when you're asked to estimate a completely new process — one that your research department has invented and developed? **Here the "Key Accounts" method of estimating process investment can be utilized.** The literature is full of data on basic equipment costs. Textbooks have been written on the subject[1] and excellent bibliographies[2] published on articles describing equipment costs. Company records also provide data from previous contract bids. Finally, vendors of specialized process equipment may be contacted to obtain the preliminary quotes. Therefore, it is possible to easily estimate the delivered cost of the basic equipment such as heaters, reactors and vessels, exchangers, pumps and compressors, instruments, etc. These items have been called the key accounts in this method as shown in Table 2. The labor required to install the key account equipment may be estimated as a percentage of the delivered material cost. In the examples shown, the percentage of materials cost required for installation of the key equipment varies, depending on the amount of field fabrication, the amount of rigging and the materials of construction of the equipment. The data for the catalytic section of a gas oil cracking plant and the atmospheric distillation plant are presented to indicate how these percentages can differ depending on the type of process considered.

Secondary accounts such as foundations, piping and insulation, electricals, structures and buildings can also be estimated as percentages of the delivered

TABLE 1. Consider these five areas to calculate total cash outlay.

1. Onsite Capital
   - Process facilities and buildings
2. Offsite Capital
   - Utilities and distribution
   - Yard facilities including site development
   - Charge stock and product storage facilities
3. Working Capital
   - Inventories
   - Cash
4. Paid-up Royalties
5. Other Cash Outlays
   - Chemical and catalyst fills
   - Start-up expense

Capacity, B/CD Charge	**10,000**	**10,000**
Overhead, Vol %	**25**	**80**
Process Investment	**$310,000**	**$470,000**
Scale Up Factor	**0.65 power**	
Stream Factor	**95%**	
Labor	**Operation in conjunction with associated unit**	
Utilities	**(Per 1,000 Bbl Charge)**	
Steam, M Lb	**35**	**84**
Power, CKWH	**0.5**	**0.8**
Cooling Water, M Gal (30° F △ T)	**120**	**280**
Maintenance 4% of Process Investment		



Note: Estimation based upon 30-tray, steel columns and a reflux ratio of one.

FIG. 1. Thumbnail sketch for gasoline splitter.

material costs for the key accounts. However, when buildings are a major part of the total investment they should be estimated separately on a square foot or cubic foot basis. Examples of these secondary account factors for a plant with both solids and vapor flow (cat cracking) and a plant with liquid and gaseous flow (distillation) are shown in Table 2. Note the wide difference in the percentages required for piping and insulation in the plant with solids flow and the distillation plant. Calculation of secondary accounts by the method outlined in Table 2 provides a more accurate preliminary estimate than a cursory examination of each account. For example, experience has shown that piping and insulation estimates are invariably low unless a complete piping layout has been made.

Let's see how . . . the key account method works in our example for a 10,000 bbl per day gasoline splitter designed to produce a 50 percent overhead fraction. A flow diagram for the splitter is shown in Fig. 2 and results of the calculation are shown in Table 3. Delivered material costs for the tower, condenser, reboiler, pumps, etc., were estimated from available data on basic equipment and updated to a 1960 basis. Total material and labor costs are estimated at about $266,000 using the method outlined in Table 2. Total estimated investment was calculated at $415,000, including overheads and fees. The key accounts method checks the $430,000 estimated from Fig. 1 within 3-5 percent after adjusting the cost in the figure from a 1958 to a 1960 basis.

Note that the total investment is not the total material and labor cost for the gasoline splitter. Items such as contractor's overhead, engineering fee and contingencies can amount to an appreciable percentage of the total cost. Contractor's overhead includes such items as administration, field office expense, equipment rental, supplies, construction shops and offices, as well as insurance and taxes. This overhead varies from about 50 percent of material plus labor on small projects to about 20 percent on large $5-10 million units. For the same total investment, overhead also varies with the amount of field fabrication required. It generally reflects a higher percentage of total cost for complex units or new process designs than for more standardized units like a gasoline splitter. Therefore, a value of 30 percent construction overhead was selected in Table 3 even though the total investment is low. Engineering usually amounts to another 10 percent of the total cost including construction overheads. Finally, contingencies of 5 to 15 percent are often included. The contractor usually includes a contingency, especially when a lump sum bid is desired. This item allows for unforeseeable situations that may develop such as difficulties in laying foundations, etc. From the owner's viewpoint in estimating the cost of the project, contingencies may also include additional items desired by the company after construction has started.

Offsite capital requirements

Offsite capital includes such items as the investment for utilities, yard facilities and storage. Many times no new investment is required for utilities when a process is installed at a development site, but distribution to the new process is always required. Nevertheless, any fair evaluation of a new proposal should include its share of the existing utilities investment used by the new process. Capacity should be sized on a stream-day basis to take care of start-up as well as on-stream demands, particularly when some of the process steam or fuel is generated by the process itself. For simplicity in refinery operations one can consider investments for fuel distribution at $10 per

TABLE 2. Key Account Method — A Tool for Estimating Capital for Experimental Processes.

Type Process	Solid and Vapor Flow (cat cracking)		Liquid and Vapor Flow (atmospheric distillation)	
Key Accounts	Materials and sub contracts	General contractor's field labor % of material	Material	General contractor's field labor % of material
Kilns and heaters	100	20	100	25
Towers	100	15	100	15
Exchangers	100	5	100	5
Vessels	100	10	100	5
Pumps, machinery	100	5	100	10
Instruments	100	30	100	30
	Total (1)	Sum	Total (1)	Sum
Secondary Accounts	Material + Labor % Total (1)		Material + Labor % Total (1)	
Piping + insulation	50		75	
All others	60		60	
	Sum		Sum	
Total Material plus direct labor				
Construction Overheads	20 to 50% of Material + Labor			
Total (2)	Material plus Labor plus Construction Overheads			
Engineering Fee	10% of Total (2)			
Contingency	5 — 15% of Total (2)			
	Total Process Investment			

TABLE 3. Key Account Method Checks Investment in Thumbnail Sketch for Gasoline Splitters.

Fresh feed 10,000 bbl per day
Overhead-bottoms = 5,000 bbl per day
Plates = 30
Reflux ratio = 1.6
Basis = 1960 (230 Nelson Index)

Key Accounts	Delivered material	Installation labor	Material + labor
Tower and trays 7 ft ID (steel)	$ 35,000	$ 5,300	$ 40,300
Exchangers 5.5 M sq ft (steel and admirality)	49,800	2,500	52,300
Reflux accumulator 35 bbl	8,000	400	8,400
Pumps and drivers	8,000	800	8,800
Instruments	7,500	2,200	9,700
Total key accounts	$108,300	$11,200	$119,500
Secondary Accounts			
Piping and insulation @ 75% key materials			$ 81,500
Others (foundations, structures, electricals, etc.) @ 60% key materials			65,000
Total Material and Labor			$266,000
Construction overheads @ 30%			$ 79,800
Engineering fee @ 10%			34,600
Contingency @ 10%			34,600
Total estimated investment			$415,000[1]

[1]Gasoline splitter from Fig. 1 estimated as $430,000 after updating to 1960 basis.

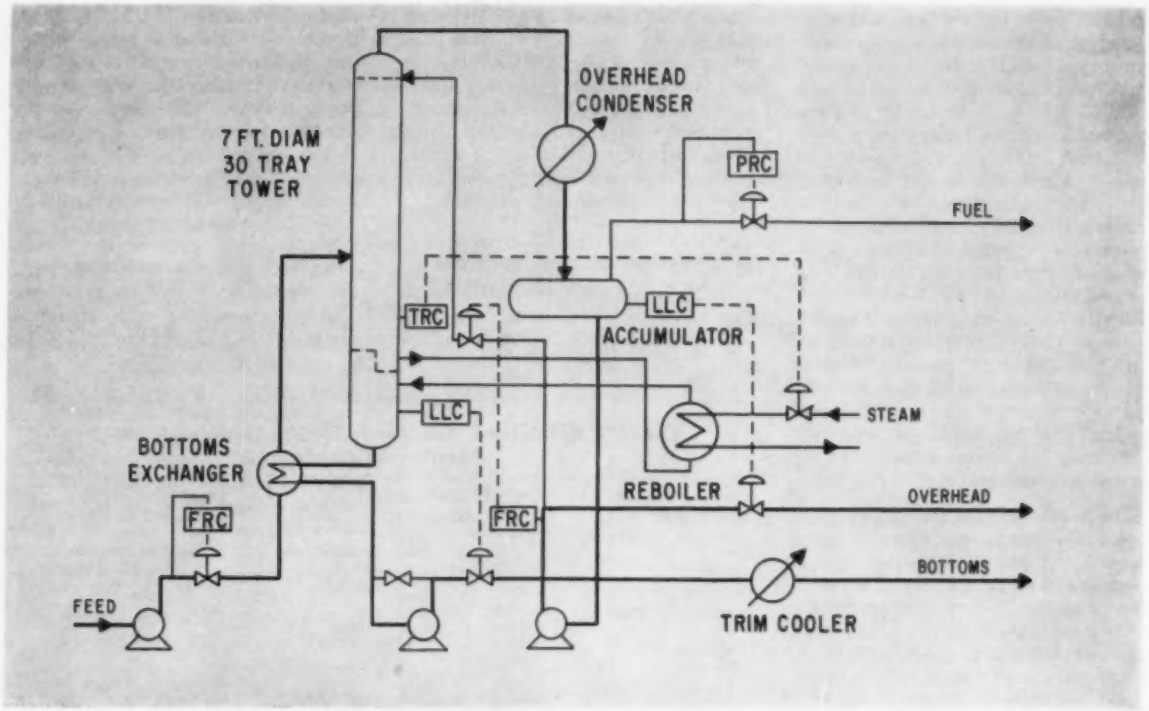


FIG. 2. Gasoline splitter — major equipment included in "Key Accounts."

million Btu per stream day, steam generation and distribution at $250 per 1000 lb per stream day, cooling water system at $35 per 1000 gal per stream day and distribution of purchased power at $250 per 100 kilowatt hours per stream day. More complete information on utility investments has been presented by Bauman.[3]

Yard facilties shown in Table 4 include those facilities required to support the proposed process. The impact on items like receiving and shipping, laboratories, and maintenance facilities should be considered even when a new process is installed at a fully developed site or refinery. These items vary from case to case and can be estimated from your own company's experience or by the methods outlined by Nelson.[4] Recent data from a completely new refinery indicate that yard facilities required 15 to 25 percent of the total capital investment. This amounts to 38 to 48 percent of the process investment in a fuels refinery. The breakdown of these facilities as a percentage of process investment is presented as a rough guide in Table 4.

TABLE 4. Yard facilities can be 38-48 percent of process investment.

	Percent of Process Invest.
Receiving and Shipping Facilities	
Docks	(10)
Loading racks and rail sidings	6
Buildings	
Maintenance	11
Office, labs, cafeteria, medical	8.5
Site, Roads and Fences	4.5
Sewers and Oil Recovery	5
Fire Protection	2
Communication	0.5
Transportation	0.5
	38 to (48)

Site cost and development are items which vary with the plant location, type of terrain, etc. The load bearing capacity of the soil also affects process investment in the type and size of foundations required. Including legal fees, industrial site costs vary from about $200 per acre in remote, undeveloped areas to about $2000 per acre in highly desirable areas on navigable waterways or with nearby rail facilities. Site development also varies considerably and is usually higher in cases where low-cost, undeveloped land is utilized. Preparation varies from $100 per acre for leveling sandy soil to $500 per acre for clearing land and as high as $10,000 per acre where considerable blasting must be done to remove rock and prepare a level site for the proposed plant. When the process is built on company-owned land, the alternate use value of the property should be included in the capital required.

Storage and stock transfer facilities for input and products is another factor which can represent a large capital investment. Recent information indicates that refiners have installed 40 to 80 bbl of storage capacity per daily barrel of throughput. The cost per barrel varies greatly depending on the type of product handled. Large 50,000-bbl tanks can be constructed for low vapor pressure fuels like heating oil or diesel fuel at an erected cost of $1.30 per bbl. Gasoline is usually stored in floating roof tanks at a cost of $2 per bbl. These costs do not include dikes, hookups, pumphouses and yard lines. For an average fuels refinery the total investment for tanks and stock transfer facilities can be $250 per daily bbl of crude run or as high as 20 to 25 percent of the total refinery investment. Storage and handling of solid materials like catalysts or chemicals depends on the type of facilities required. Bulk storage in silos can be provided for approximately $0.50 per cu ft, but bagged or packaged chemicals require warehouse storage at an investment of about $2 per cu ft of material stored plus additional facilities for handling. This warehouse investment allows for necessary access aisles and other normal freespace.

Working capital

In addition to fixed capital and land investment, additional funds or working capital must be made available to keep the project operating. Working capital should consider inventories, cash, accounts receivable and payables including an allowance for taxes. It is not unusual for a refinery to have crude inventories large enough to last several weeks and inventories of seasonal products like heating oil large enough to last three months or longer. An allowance for inventories of catalysts, chemicals and maintenance parts should also be included. Working capital thus represents a real cash outlay although the risk of obsolescence is usually somewhat less than that for the plant investment. This is particularly true if the materials are commodities which have intrinsic values as high as their cost. Platinum used in reforming catalyst is an example. First cost is high, about $80 to $85 per troy ounce. Since the platinum can be recovered at any time (the platinum market is relatively stable) its cost cannot be depreciated and therefore, should be considered working capital. The cost of platinum recovery, of course, can be expensed and is usually considered part of the catalyst replacement cost.

In addition to the funds tied up in inventories, working capital should also include cash or marketable securities. The costs for plant operation must be met until payment is received for products sold. Many companies set the ratio of cash to accounts payable at 1.0. In order-of-magnitude estimates, cash as working capital should permit normal plant operation for 60 to 90 days.

Process royalties

Royalty payments for a new process are handled on both paid-up and running bases in the petroleum industry. Most licensors give an option on process royalties and the choice usually depends on your company's policy. Paid-up royalties are usually amortized in a 5-year period on a tax-free basis. Running royalties are expensed and are usually paid at 3-month intervals. These factors can affect the choice of royalty selected, particularly when the time value of money is considered in the evaluation.

Other cash outlays

Start-up expense includes the training of new operators and operating costs for that period of time required to bring the plant to a reasonable level of production. Experience has shown that a well-engineered plant can usually be brought to a satisfactory production level in two to four weeks, provided the process is based on a standard-type design. Therefore, capacity input costs for a one-week period and direct plant expense for a three-week period are suggested as a guide for the preliminary appraisal.

Five outlays described all contribute to the total cash outlay required to initiate a project. It permits management to visualize the type financing required, i.e., from reserves, long term notes, or additional capitalization. Furthermore, analysis of the detailed items in the total cash outlay permits management to assess the over-all risk involved in the project. Obviously, the funds required for utilities, site and storage facilities will not be subject to the same rate of technical obsolescence as the investment in the process facilities.

TABLE 5. Consider these three components of manufacturing expense.

1. Operation
   - Payroll including benefits
   - Utilities
   - Catalyst + Chemical make-up
   - Containers
   - Supplies
2. Maintenance
   - Materials
   - Payroll including benefits
   - Contracts
3. Additional Expense
   - Local taxes and insurance
   - General overheads

TABLE 6. Does the project affect these overheads?

1. Top management
2. Technical staff assistance
3. Laboratory other than control tests
4. Employee relations
5. Medical
6. Cafeteria
7. Accounting
8. Security
9. Other facilities and services

Manufacturing expense

Estimate of the total cash outlay required to initiate a project is usually only the first step in the evaluation. The cost of operating and maintaining the plant are equally important in determining the profitability of a new venture. Rapid estimates of manufacturing expense can be made by following the form outlined in Table 5. Operating expense includes operating payroll, utilities, catalyst and chemical make-up costs, supplies and containers. The payroll includes operators' wages, and an allowance for direct supervision, technical and clerical help, including all employee benefits. These additional items can increase the direct hourly wage some 50 to 70 percent. However, including all these items in one factor permits total operating payroll to be estimated on the basis of men per shift required for the operation. Estimates of direct operating labor can be made rather accurately once the process has been described. The estimator should take into consideration the operation of furnaces, refrigeration equipment, etc., which require licensed operators. The amount of automatic control, the physical handling of materials and the

Meet the authors

EDWARD A. SCHRAISHUHN is presently supervisor of the research planning staff for Socony Mobil Oil Company, Inc. This staff helps guide the research program through preliminary appraisals of new ideas and evaluation of current developments. All cost estimates for other purposes are made by the corporate engineering department in New York. Schraishuhn received both his bachelor's and master's degrees from the University of Pennsylvania. Following a tour in the Navy, he joined the research department of Socony Mobil at Paulsboro, New Jersey, and worked in both process development and economics evaluation before advancing to research planning work.

JOHN KELLETT is senior technologist in the research planning staff of Socony Mobil, specializing in the evaluation of petroleum chemicals and catalyst research programs. He joined the Socony Mobil research department after graduation from Lehigh and worked five years in petroleum chemicals research and development. He then attended the University of Pennsylvania, where he obtained a PhD in chemical engineering before rejoining the company in his present position.

tests required on the product should also be considered. Moreover, plant safety codes usually require that at least two men work together in isolated operations. This restriction seldom increases the number of operators required, if the plant is laid out efficiently.

The direct costs for operating utilities are usually available from accounting data within a plant. These costs are usually applied directly in preliminary estimates. If large quantities of steam and cooling water are required for a new project, their cost can be estimated on the same basis as that for a process.

Catalyst and chemical make-up charges should be based on maintaining inventories of these materials at a constant or safe level throughout the process life. These costs can also be converted to a daily or unit-of-product cost for the simple estimate. If the time value of money is considered in more detailed evaluations, these materials are represented as cash flows only at the times replacement is required.

Containers and packages are usually omitted when bulk shipments of fuels or lubes are made. However, these costs can be significant when considering small volume or perishable products. Supplies such as safety equipment and special clothing are usually a small part of the total cost. They are a function of both labor requirements and the complexity of the operation. Rapid estimates of this item can be made on an annual basis of ½ percent total labor including maintenance labor plus ½ percent of capital investment.

Maintenance costs vary considerably with the type of process. Several studies[5] have been made to assess critical factors such as the temperature and pressure of operation, amount of mechanical equipment, and the corrosive nature of reagents. However, most refinery processes require maintenance expenditures of 3 to 6 percent of investment per year with about two-thirds of the total expense related to the labor component. Since this labor component is high, some companies have recently contracted maintenance at new installations. This method has particular advantages where the maintenance manpower requirements vary substantially due to seasonal unit turnarounds.

Additional plant expense includes taxes and insurance as well as administrative overheads. Taxes and insurance usually amount to 1½ to 2 percent of investment per year, depending on local tax policies and the type of insurance carried. General plant overhead includes those items in Table 6. Note that if a new process is being installed at a development site, very few additions to overhead should be required. However, in a typical fuels refinery these overheads may be as high as 2 to 3 percent of the capital investment annually. In plants where labor is a major factor the annual overheads may be roughly estimated as 25 percent of direct operating and maintenance labor plus ½ percent of total investment.

Input costs and production values

Input costs are defined in many ways by estimating groups. Therefore, it appears desirable to define this term adequately so that no significant omissions will occur in the evaluation. For the purposes of our work, input costs are defined as received materials that appear in the finished products. Antiknocks and other additives are included here as well as raw materials like petroleum base stocks and crude. Catalysts and chemicals which are consumed in the process are listed under Manufacturing Expense as noted in Table 5.

Production value may be estimated for the various products from material balances and unit prices discounted for marketing costs. However, the cost or desired price for the product is often the required answer in preliminary evaluations. The method selected for the evaluation at this stage depends on the objective of the study and the alternatives offered.

Evaluation or appraisal

Now that the cost estimates are complete, the process planner can evaluate the project. This is the so-called climax of the study where the fruits of our efforts are realized (or crushed if the answer is unfavorable). Therefore, a very brief discussion of the techniques applicable in preliminary planning are presented here, although this is the subject of a paper by Happel and Kapfer in this symposium.

Depending on the objectives of the study, management may want to know one or more of the following after assessing market characteristics and the project's over-all risk from the technical and economics viewpoints:

1. Product cost versus rate of return.
2. The effect of critical process variables like production volume on the rate of return or product cost.
3. Value of the feedstock at an estimated production value and rate of return.
4. Allowable investment or operating cost at a given rate of return.

The technique used to determine or estimate the rate of return can vary depending on the accuracy required and reliability of the data available. An allowance for capital recovery or payout after income tax can be estimated quickly from the capital and expense items outlined above. The payout method usually neglects the cash flow pattern and the time value of money. If the time value of money is considered, the rate of return can be estimated by present worth type calculations,[6] once the cash flow pattern is developed. If your company has access to a computer station, these trial-and-error calculations can be programmed to provide rapid solutions and also to investigate the critical variables in the study. The discounted cash flow method has an advantage in that it forces the planning engineer to consider the timing of expenditures and incomes over the life of the project. This usually provides a more realistic and accurate appraisal of the process.

Estimates of the total cash outlay and total manufacturing expense are important steps in the preliminary appraisal of new projects. These items include more than just the battery limits process investment and operating costs. They include analyzing the impact of the new process on the existing facility and its integration into the entire plant. Use of the checklists in Tables 1 through 6 will prevent the engineer from overlooking important cash flows even in preliminary appraisals of new projects.

Acknowledgment

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JOHN HAPPEL

W. H. KAPFER

Evaluate plant design

This simple index is offered to design engineers as a means to project evaluation as well as optimizing plant design alternates. The authors fully discuss how to use this index and then offer solutions to three typical design problems that really put their idea to work.

OFTEN THE SELECTION of methods to evaluate overall investment in new projects is handled as a separate problem apart from optimum design of the component parts of the plants under consideration. Here is a criterion which will result in a consistent evaluation procedure.

For simplicity, in order to direct attention to the method itself, development here is confined to the simple situation where the same rate of return is presumed each year for the entire project life, thus avoiding the necessity for evaluation of a series of future annual returns. Other simplifications include the assumption of no change in working capital due to acceptance or rejection of the project and no salvage value for the process equpiment at the end of its useful life. It is easy to take these items into consideration[1] but, of course, a more complicated form of relationship then results.

The premise developed here is that in a going business the attractiveness of a proposed new venture is measured by the incremental total return above an annual rate of return, i_m, currently considered attractive in view of both the technological and business risks involved. This incremental total profit per year, which is the driving force attracting new capital, is called **venture profit.** It is defined as follows:

$$V = P - i_m I = R - eI - t(R - dI) - i_m I \quad . \quad . \quad (1)$$

where:

V = Venture profit, $/yr.

R = Gross income, $/yr. This item refers to yearly earnings from a venture assumed constant throughout its operating life. It is equal to sales realization less raw material costs, operating expenses, overhead, maintenance, social security and unemployment taxes. However, it does not include deductions for depreciation or federal and state income tax.

P = Net profit after depreciation and taxes, $/yr.

I = Total investment, $.

t = Federal plus state income tax, fraction/yr.

d = Depreciation rate allowed by government, fraction/yr.

i_m = Minimum acceptable return rate, fraction/yr.

e = Depreciation rate based on actual obsolescence, fraction/yr.

Equation 1 gives a yardstick for making a rational decision regarding capital investment on the basis that the alternative which results in the largest value of V is the most attractive. Sometimes there are a number of possibilities for capital investment which are not mutually exclusive. Such propositions include those where a decision to engage in a given investment opportunity does not preclude similar expenditures for other alternatives. For example, the allocation of funds to a given research project or new commercial venture in a given area may not prevent expenditures on other products or in other areas. All such projects will be considered attractive which give a positive value for V, since they yield a return greater than the minimum acceptable return. This amounts to assuming that unlimited capital is available at the minimum acceptable return rate, i_m. If the number of attractive propositions exceeds the firm's access to funds, then it is necessary to choose the total projects approved so as to take this additional restriction into consideration. In effect this situation is equivalent to assuming a sharp rise in i_m beyond a certain capital commitment.

Meet the authors

JOHN HAPPEL, chairman of the chemical engineering department at New York University, served Socony-Vacuum Oil Co. in various technical capacities for 17 years before coming to NYU in 1948 as a full professor. He is author of numerous technical papers and book chapters on gasoline manufacture and production of butadiene and other chemicals and is credited with a score of patents on petroleum subjects. He holds a BS in chemical engineering and MS in chemical engineering practice from Massachusetts Institute of Technology and doctorate in chemical engineering from Polytechnic Institute of Brooklyn.

WILLIAM H. KAPFER, associate professor of chemical engineering at New York University, rates chemical engineering economics and plant design among his principal fields of interest. He received bachelor's, master's, and doctor's degrees from NYU and served as a chemical engineer for Hercules Powder Company from 1941 until 1949. He has been a full-time member of the NYU chemical engineering faculty since January 1952, engaged in teaching, academic and applied research, and consulting work.

with this simple index

On the other hand, as is often the case in plant design problems, one may be considering a number of mutually exclusive alternatives. A mutually exclusive proposition is one where making any one choice precludes the possibility of choosing the others. For example, each choice of a given surface for a heat exchanger to accomplish a specific service excludes the possibility of installation of exchangers of other sizes. In this case the choice giving the highest value of V will be the proper one. Such a choice can be made by simple comparison of alternatives but is often facilitated by the use of mathematical techniques for optimization. In the case of investment opportunities both for entire plants and for their component parts, it is important to take into consideration the alternate which involves doing nothing. In the method of evaluation employed here, the choice of this base case alternative is the same as assuming that the available capital will simply be reinvested at the firm's current return rate in its existing business rather than in a new higher risk venture.

One way of making a design choice which is often used by engineers is to compare alternatives for a plant design in order of increasing investment involved. It is easy to show that for any two such propositions in a series the application of the venture profit concept is equivalent to the familiar procedure which requires incremental investment to show a return rate at least equal to the minimum acceptable return rate.

Thus suppose the two cases are designated by the subscripts numbered 1 and 2 respectively. Then we will have

$$V_1 = P_1 - i_m I_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$V_2 = P_2 - i_m I_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

If the proposition designated by subscript 1 is better than that designated by subscript 2, we must have $V_1 > V_2$ or $\Delta V = V_1 - V_2 > 0$ If we subtract Equation 3 from Equation 2,

$$\Delta V = \Delta P - i_m \Delta I \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and if $\Delta V > 0$, then $\Delta P > i_m \Delta I$, so that

$$\frac{\Delta P}{\Delta I} > i_m \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

That is, the incremental return rate on the incremental capital invested must exceed i_m. Venture profit accomplishes the same type of comparison without requiring step by step comparison of each increment of investment.

For many purposes it is possible to employ further simplifications in applying Equation 1. Thus we may assume that government tax agents will allow a plant life which agrees with the prediction of management based on business considerations, and that for tax purposes straight line depreciation will be used. Thus, if the plant life is "n" years, the depreciation rate for tax purposes will be $d = 1/n$. However, depreciation from the company standpoint takes the form of the sinking fund deposit factor:

$$e = \frac{i}{(1+i)^{n-1}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

The interest rate i used in Equation 6 is defined as the average rate of earnings on all the company's invested capital. Note that i_m, the minimum acceptable return rate on a new project, will usually be higher than i since it depends on the risks involved in technological failure and obsolescence. The sinking fund deposit factor gives a series of appropriate equal annual payments which, at compound interest rate i, will just equal the value of the initial investment at the end of the plant life. A rough approximation for this factor applicable for $i = 0.05$ to 0.15 and $n = 1$ to 20 is as follows:

$$e = \frac{i}{(1+i)^{n-1}} = \frac{1}{n} - 0.35i \quad . \quad . \quad . \quad (7)$$

If these substitutions for d & e are made in Equation 1, we obtain

$$V = \left[R + \left(\frac{1}{n} + \frac{i_m - 0.35i}{1-t} \right) I \right] (1-t) \quad . \quad . \quad (8)$$

Some further explanations may be in order regarding the distinction between i_m and i. The rate i_m may be considered applicable to the original capital investment I. The project can be visualized as "borrowing" the sum I from the firm for a period of the anticipated plant life. Thus we assume that when management is presented with an opportunity to invest risk capital of $1,000,000 and specifies $i_m = 0.15$, this is equivalent to the statement that management would require net earnings of $150,000 per year for the anticipated plant life. In the case of an ordinary investment in securities, the $1,000,000 would also be returned at the end of the investment period. Since the salvage value of a process plant at perhaps a nominal life of 12 years will be practically zero, the question arises as to how provision should be made in the evaluation procedure to make the evaluation of a plant investment opportunity comparable with investments where the original capital is returned at the end of the investment period. This is commonly accomplished by means of sinking fund payments such as given by Equation 6. The sinking fund will be invested at an appropriate interest rate, which may be considered as an opportunity for the project to "lend" money to the firm. This interest rate may be taken equal to what the company is normally obtaining on similar investments in its current business, viz., i. It does not appear proper when one compares two different investment opportunities to use different rates at which sinking fund money can be reinvested for the purpose of recovering initial investment. This reinvestment does not usually involve the same risk as that connected with the original capital investment proposal.

In cases where the venture profit V varies from year to year it is possible to judge attractiveness by a summation of the profits obtainable each year, using compound interest to bring all profits to a common reference time[1]: Any reference time may be chosen but the present is usually most convenient. All future venture profits are thus discounted to the present at the rate i, and the summation obtained serves as the index of attractiveness of the alternatives involved. This criterion differs from other methods proposed for evaluation of project attractiveness.[2] Thus the so-called "interest rate of return" and "present worth" methods each employ only one interest rate, instead of the "borrowing rate," i_m, and "lending rate," i, as used in the method discussed here. It is, of course, more difficult to reduce economic concepts to a simple quantitative form which is generally acceptable in the same sense as many technical calculations. However, it is believed desirable to distinguish between situations involving the risk associated with new ventures and that associated with normal business.

In the method proposed here, only one "borrowing" rate is employed and it is assumed applicable to the original investment opportunity. "Lending" is taken at the rate i as funds accumulate due to profitable operation of the project. Single propositions requiring capital investments at future times should in principle be evaluated in terms of specific "borrowing" rates appropriate to the time, length of period and risk involved in the capital requirement. Mathematically, situations involving "borrowing" and "lending" with various restrictions can be elaborated to any desired extent,[3] provided the basic information is available to establish the appropriate rates. For many practical situations substantial capital investments in the early years of a project can all be assumed to be committed at the outset at the rate i_m since the risk of loss will not be established until after the project is in full operation and all such funds are expended. If the appropriated funds are not immediately used during the first few years they can be considered to be reinvested during this initial period at the rate i. Similarly maintenance expenses occurring later during project life will naturally take place after the project has been operating for some time and the major risks above those entailed in current business are past. Thus they will be obtainable at the lower rate i.

For plant design purposes, additional simplifications are sometimes useful. Thus the overall sales may be assumed not to be affected by details of plant design as long as specification product is manufactured. Annual maintenance may often be taken as a percentage of investment. Thus, we set

$$R = S - C - mI \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

where,

S = Total sales realization, $/yr (assumed constant).

C = Running operating expenses, $/yr.

m = Maintenance rate, fraction/yr.

If this substitution is made in Equation 8,

$$U = S - \frac{V}{1-t} = C + \left[m + \frac{1}{n} + \frac{i_m - 0.35i}{1-t} \right] I$$

$$. \quad . \quad . \quad . \quad . \quad . \quad (10)$$

The quantity at the left side of Equation 10, U, is the annual total cost before taxes, $/yr. It will obviously be a minimum if V is set at a maximum, since S and t are assumed constant. For a plant design project involving mutually exclusive alternates, therefore, the one giving the minimum value of U is selected. The investment dependent item in parenthesis (the multiplier of I) in Equation 10 may be thought of as a "fixed-charge." In many cases reported in the technical literature a similar fixed charge on investment is employed, but often the term $(i_m - 0.35i)/(1-t)$ is omitted, so that no allowance is made for anticipated profit required for the new investment.

Example 1.

Problem . . .

The determination of optimum boiler blowdown is important in the design of feedwater treating facilities for steam generators of all types. As the percent blowdown is reduced, less heat is wasted and less feedwater is used, but at the same time the investment in water treatment facilities and the operating costs for producing higher quality water increase. The economic balance here is readily made in terms of the venture profit concept, using the blowdown data of Prater and Antonacci *(Pet. Ref.,* 38, No.10, p. 119, Oct. 1959) in conjunction with water softening investment and cost data from Vilbrandt and Dryden, "Chemical Engineering Plant Design," McGraw-Hill, N. Y. (1959), Aries and Newton, "Chemical Engineering Cost Estimation," McGraw-Hill, N. Y. (1955), and Zimmerman and Lavine, "Chemical Engineering Costs," Industrial Research Service, Dover, N. H. (1950).

Pertinent data, obtained from these sources, are given in Table 1.1.

Table 1.1

Total Solids in Feedwater ppm	% Blowdown Req'd to maintain 3000 ppm max. solids	Heat Loss MM Btu/hr	Feedwater Req'd[a] m gal/hr	Estimated Cost of Water Treatment $/m gal	I= Estimated Capital Investment for Water Treatment $
500	20%	45	75	0.02	150,000
400	15	37	70.6	0.04	175,000
300	11.5	31	67	0.06	200,000
200	7.5	19	64.1	0.08	225,000
100	3.0	7	62	0.10	250,000
50	1.8	4	61	0.12	275,000

[a] $\text{Feedwater req'd} = 500{,}000 \ \frac{\text{lb steam}}{\text{hr}} \div \left(1 - \frac{\%\ \text{blowdown}}{100}\right)$

If the cost of coal is $6.70 per ton, the cost of heat at 79 percent fuel efficiency becomes

$$\frac{670}{13{,}500(2000)(0.79)} = 31.5 \text{ cents/MM Btu} = \text{cost of heat}$$

A steam boiler is assumed to generate 500,000 lb per hr of steam at 700 psia and 850 F with a fuel efficiency of 79 percent on coal having a heating value of 13,500 Btu per lb. It is desired to determine the optimum percent blowdown and feedwater solids content, to keep below 10 percent blowdown and a limiting concentration of 3000 ppm dissolved solids.

Solution . . .

Now assuming a 20-year equipment life, 52 percent federal tax plus 3 percent state and local taxes (= 55 percent total tax), average company earning rate, i, of 10 percent, minimum acceptable return rate, i_m, of 15 percent for this installation, and maintenance charges of 6 percent based on capital investment, we have from Equation 10:

$$U = C + \left(m + \frac{1}{n} + \frac{i_m - 0.35i}{1-t}\right) I$$

$$= C + \left[0.06 + \frac{1}{20} + \frac{0.15 - 0.35(0.10)}{1 - 0.55}\right] I$$

or

$$U = C + 0.366\, I$$

where C is now the total annual running cost of water treatment plus the heat loss by blowdown, and I is the capital investment in the feedwater treating plant.

Using the above relationship and data, therefore, we may tabulate as follows (Table 1.2):

Table 1.2

Total Solids in Feedwater ppm	Annual Cost of Heat Loss from Blowdown $/yr	Annual Cost of Water $/yr	C Total Annual Cost of Heat and Water Treatment $/yr	0.366 I Investment Cost $/yr	U = C+0.366 I $/yr
500	124,000	13,100	137,100	55,000	192,000
400	112,000	24,000	136,600	66,100	202,700
300	85,300	35,200	120,500	73,200	193,700
200	52,400	45,000	97,400	82,400	179,800
100	19,300	54,200	73,500	91,500	165,000
50	11,000	64,000	75,000	101,000	176,000

Since the venture profit is a maximum when U is a minimum, it is thus seen that the optimum occurs at or near 100 ppm solids in the feedwater, corresponding to about 3 percent blowdown.

Example 2.

Problem . . .

A problem which is often met in chemical engineering practice, and especially in petrochemical processing, is the decision between continuous and intermittent production. In one form of this problem a choice must be made between several plant sizes by comparing the increased investment costs for larger equipment with the savings in labor costs obtained by evening or weekend shutdowns in batch type operations. This case, which has been treated by Weaver and Lyndall in an article entitled "Round the Clock or Weekends Off?" (*Ind. Eng. Chem* 50, No. 5, p. 61A, May, 1958), furnishes an additional example of the present method, which may then be compared to their published method.

Solution . . .

As shown earlier, the venture profit concept is actually simpler, since it avoids the necessity of making a more cumbersome incremental analysis, and it also takes into account

Table 2.1

Case	A	B	C	D	E
Shifts/day	3	3	3	2	1
Days/week	7	6	5	5	5
Hours/Year	8760	7512	6264	4176	2088
I = Fixed Investment	$1,000,000	1,100,000	1,220,000	1,560,000	2,370,000
C = Labor Variable Costs $/yr					
C_1 = $10/hr	$ 88,000	$ 75,000	63,000	42,000	21,000
C_2 = $20/hr	$175,000	150,000	125,000	84,000	42,000
C_3 = $30/hr	$263,000	225,000	188,000	125,000	63,000
C_4 = $40/hr	$350,000	300,000	251,000	167,000	84,000
C_5 = $50/hr	$438,000	376,000	313,000	209,000	104,000

the difference between the minimum acceptable return rate, i_m, for the specific project and the average earning rate, i, for the company as a whole. The "interest rate of return" method does not make this distinction, and in effect uses an arbitrary value of interest rate, which just extinguishes the venture profit, thus making comparison of alternatives more difficult.

The results of the analysis by both methods show relatively small differences in the present illustration, but it will be appreciated that by varying the basic assumptions substantial differences could result.

Thus, using the basic data given by Exhibit 1, in Weaver and Lyndall's paper, we have for 5 cases the following plant investments and labor variable costs (Table 2.1).

By Equation 10 of the present article

$$U = S - \frac{V}{1-t} = C + \left(m + \frac{1}{n} + \frac{i_m - 0.35i}{1-t}\right) I$$

where S is the same for all cases

C = Labor variable cost in all cases as given in Table 2.1

$n = 15$ years; $d = \frac{1}{n} = \frac{1}{15} = 0.0667$

m = 5⅓ percent

t = 50 percent federal tax + 2 percent local taxes = 52 percent total income tax

These assumptions are the same as those of Weaver and Lyndall. In addition we will assume

$i_m = 15$ percent

$i = 10$ percent

Then the term

$$\left(m + \frac{1}{n} + \frac{i_m - 0.35i}{1-t}\right) \text{ in Equation 10 becomes}$$

$$\left(0.0533 + 0.0667 + \frac{0.15 - 0.35(0.10)}{1-0.52}\right)$$

$$= \left(0.120 + \frac{0.115}{0.48}\right) = 0.36$$

and Equation 10 reduces to

$$U = C + 0.36\,I$$

where minimum U corresponds to maximum venture profit, V.

Using Weaver's data for C and I from Table 2.1 the values for U in each case are calculated and shown in Table 2.2. For example, in Case A at labor variable costs of $10/hr, C_1 = $88,000/yr. Hence $U_{1,A}$ = 88,000 + 0.36(1,000,000) = $448,000/yr.

Table 2.2

Case	A	B	C	D	E
Shifts/day	3	3	3	2	1
Days/week	7	6	5	5	5
I, $	1,000,000	1,100,000	1,220,000	1,560,000	2,370,000
0.36 I, $	360,000	398,000	439,000	561,000	854,000
U = C + 0.36 I, $/yr					
U_1(At C_1 = $10/hr)	$448,000*	473,000	502,000	603,000	875,000
U_2(At C_2 = $20/hr)	$535,000*	548,000	564,000	645,000	896,000
U_3(At C_3 = $30/hr)	$623,000*	623,000*	627,000	686,000	917,000
U_4(At C_4 = $40/hr)	$710,000	698,000	690,000*	728,000	938,000
U_5(At C_5 = $50/hr)	$798,000	774,000	752,000*	770,000	958,000

The starred values (minimum U in each case) in the above table represent optima. As a single point of comparison it will be noted that for $30/hr labor variable costs under the stated conditions, using a minimum acceptable return rate of 15 percent ($i_m = 0.15$), that either Case A (7 day operation on three shifts) or Case B (6 day operation on three shifts) give minimum values of U, and hence maximum venture profit, V, whereas Weaver and Lyndall conclude that Case B should definitely be the choice. This result is obtained because their method, by using a higher average discount rate on capital (15 percent versus 10 percent by the present method), overemphasizes the economy which can be effected by labor saving.

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The right COS can reduce pumping costs

COST REDUCTION pertinent to centrifugal pump purchase and operation is an extremely popular cause today. Extensive studies have been undertaken into many areas including first cost, repair parts, parts inventory, and even to standardize designs. Certainly these studies have merit and can be very rewarding, but an even more promising area often lies unexplored. This area is the accuracy and completeness of the **Conditions Of Service (COS)** used in requisitioning pumps. These conditions represent the foundation of economical pumping and care in their compilation can show the way to real savings in pumping costs.

The Ideal Situation . . .

The desired objective in a centrifugal pump application is a good match between the pump's characteristics or capabilities and the system requirements. Fig. 1 illustrates a simple system and a relationship between the static head and friction loss components that make up a system head curve. The static head, of course, includes differences in pressure and/or elevation between the pump suction and discharge. The friction loss must include losses through piping, valves, fittings, exchangers, etc. The relative proportions of static head and friction loss do vary from system to system, and may even vary in a given system from time to time. **These facts are commonly known, but not too conscientiously observed.** This is the point where cost reduction in pump applications should begin.

A centrifugal pump has a familiar characteristic such as shown in Fig. 2, which is regarded as self-explanatory. We have identified point (A) to represent a typical design point based on service conditions in an inquiry data sheet. The information on this data sheet would be derived from an estimate of system needs as exemplified by Fig. 1.

In an ideal system point (A) would be an exact indication of the system requirements and the specified pump characteristic curve would intersect the system head curve at this point. This is the most economical pumping condition since the system demand and the pump capabilities are matched.

Different valve settings indicated by dotted lines in Fig. 1 vary the friction loss component and thereby alter the point of intersection between the pump curve and the system curve. Changes in the static components have comparable effects. The magnitude and extent of such variations should be accounted for if the specified pump design conditions are to be realistic and truly economical. **Designing for extremes is uneconomical** . . . in both first cost and operating costs.

Inadequate System Data . . . Its Consequences

Let us step back from the ideal and consider another type of system analysis where the various components are not carefully estimated. Presume that the static head and the friction losses are over-estimated. In addition, the design capacity is likely to include some margin for contingencies. All of this could add up to point (A), the specified design point, whereas the actual system requirements might be more like point (B) illustrated in Fig. 3. The difference between the pump capabilities and the system demand must be throttled off with a tangible waste of horsepower at all operating conditions. Also, consider the prospect that oversized pumps and drivers may be installed to meet the mythical design point (A). This is a very common penalty for overestimating service conditions.

A careful system analysis should precede the preparation of the inquiry data sheets for maximum benefits. However, savings can be realized in the operating costs of existing equipment by better matching impeller diameters to system needs. This saving could probably approximate 10-15 percent of the annual pump power consumption in most plants.

What About Maximum Diameters . . . ?

Because of the foregoing circumstances, pump specifications which arbitrarily rule out maximum diameters should

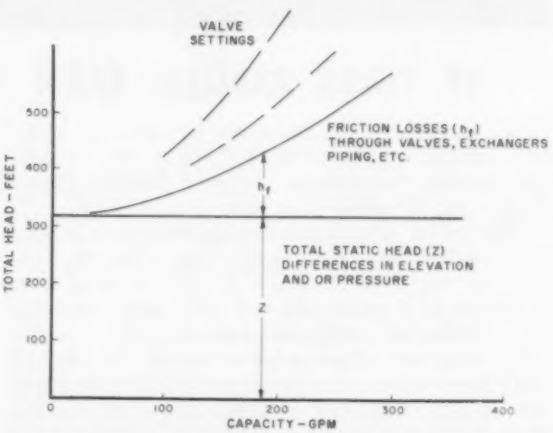

FIG. 1. Typical system-head curve showing the relationship between losses in system components. Such a plot is useful in analyzing systems with varying load requirements to determine the most economical pumping conditions.

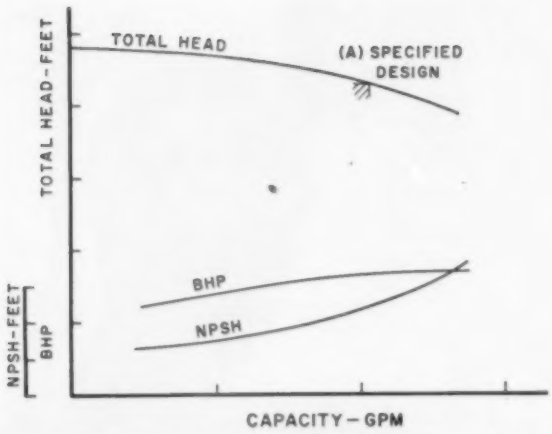

FIG. 2. A typical centrifugal pump curve. The fact the NPSH requirements are lower "back on the curve" can lead to oversized pumps when you understate your NPSH available.

be re-examined. In most cases the specified **design** conditions are far on the safe side with an allowance of 10-20 percent excess capacity and possibly a similar margin on the total head. In practically every case the operating range is substantially below the inquiry design conditions. This practice in itself can lead to situations exemplified by points (A) and (B) in Fig. 3, even without an accidental overestimate of the system components.

It often occurs that the best selection will require a maximum or near-maximum diameter to meet your specified design conditions. When your specifications discourage such selections, you will pay a double bogey for larger pumps in higher first cost and, generally, lower efficiencies in your operating range. The magnitude of these excess costs will vary with different service conditions. In every case, however, this is a deviation from the desired objective of the best match between the pump and the system.

Other penalties may be exacted in insidious ways. Service life could be reduced by corrosion or erosion problems aggravated by operation away from the best efficiency point. This is due to increased recirculation within the pump which

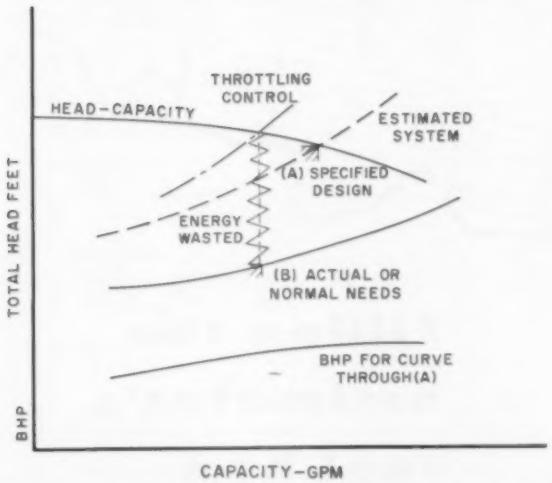

FIG. 3. An example of the energy wasted when a pump capable of meeting design point "A" is applied on a system with lower requirements, such as "B." This can result from over-estimating conditions by not allowing for varying conditions or from poorly assigning multiple spare pumps.

can also cause noise and vibration. And, stuffing box operation can be impaired by increased shaft deflections at low operating capacities.

We suggest a reorientation of opinion with regard to this specification so that the real objective of a good match between the pump and the system takes proper precedence over any artificial diameter restrictions. This is a real key to economical pump applications.

Suction Conditions

Special attention is justified in studying the suction components of your system carefully to assure accurate data on the NPSH available. This is a well-known prerequisite to satisfactory installations, but there can also be economic advantages in providing realistic data to the pump suppliers.

We cannot cover here all of the facets of NPSH, but will restate only the basic relationship. NPSH required is part of a pump characteristic as shown by the curve in Fig. 2. The NPSH available, a system characteristic, must equal or exceed the NPSH required or vaporization will take place at the impeller entrance. This is the suction condition responsible for erratic pump delivery, noise and vibration which are characteristic of cavitation.

Because of this relationship, there is a common tendency to understate the NPSH available and thereby leave in an extra margin of protection against cavitation. This practice can be advantageous, but it can very easily be carried to an extreme. The best approach is a careful estimate of the suction side so that the true suction conditions are known.

MEET THE AUTHOR

TED SNIFFEN, with Harrison Division of Worthington Corporation, is responsible for centrifugal pump sales to the industrial and process markets. He has been with the company since his graduation from Newark College of Engineering in 1949 with a BS in mechanical engineering. Sniffen is a licensed engineer in Texas, and is interested in ASME and API activities.

Fig. 2 shows that understating the NPSH available can lead to the purchase of oversized pumps. This is so because the pumps would be selected "back on the curve" where less NPSH is required. The familiar economic consequences of oversized pumps — higher first cost, lower operating efficiencies and larger drivers — appear immediately on the scene. And we must also consider that the entire situation can be complicated by excesses in the design condition as discussed in the preceding paragraphs.

In some installations, the suction conditions will cycle widely during operation. It is good practice to examine the cycle of variations to see if a compromise design condition can be worked out, rather than restricting to the extreme situation. For example, the "normal" NPSH available may permit operation at design flows, with throttling required to restrict the pump to lower capacities under extreme suction condition.

Complete data on NPSH variations along with pertinent comments will help the manufacturer to make the most economical selection.

Suggested Action . . .

A review of the methods used in compiling pump design conditions is in order. Such a study would shed light on the amount of conservatism now included in the specified COS. It could also stimulate an awareness of the importance of matching the pump to the system in the most practical manner. **This must be the foundation for truly economical pumping installations.** ★ ★ ★

Contract
Page

Location:

Customer:
Description:

DIRECT FIELD COSTS A/C No.	Description	Quantity Estimate	Quantity Actual	ESTIMATED COSTS Labor	ESTIMATED COSTS Material	ACTUAL COSTS Labor	ACTUAL COSTS Material	UNIT COSTS Labor	UNIT COSTS Material

Filling the estimator's tool box

FIG. 1. Suggested form for cost reports.

WILLIAM I. McKAY, *Manager, Estimating Department*
The Fluor Corporation, Ltd., Los Angeles, California

FROM AN ESTIMATOR'S STANDPOINT, few kinds of work are as complex as estimating for petroleum processing units. A large tool kit of unit cost information is required in order to "build" an accurate estimate. Constructors can buy all of the construction tools they need on the open market. But where can the estimator buy his tools? They are "bought" by spending time and money for cost records from past projects. Contractors all too often have spent thousands of dollars for construction tools but little for estimating tools. Both sets of tools are equally important.

Here is an outline and discussion of the preparation of cost reports . . . or estimating tools. The discussion is limited to refinery construction, although in principle it would apply to any phase of the construction business.

Cost reporting is much more than merely tabulating final book costs. It is a measure of a given unit of work accomplished that embodies all favorable or unfavorable conditions which affect work. Book costs, then, must be correlated to quantitative accomplishment as well as to working conditions.

Outline for Cost Reports

It is important to attain uniformity in reporting. The need for standardization cannot be over-emphasized. If costs from one project are to be compared with costs of another project, the costs must represent similar components. A suggested outline for cost reports prepared upon job completion follows:

I General
- A. Scope of work
- B. Type of contract
- C. Chronology

II Specific Conditions
- A. Physical features of job
- B. Site conditions
- C. Weather
- D. Items furnished by client

III Methods
- A. Temporary facilities
- B. Sub-contract
- C. Construction equipment
- D. Erection procedures

IV Labor
- A. Labor conditions
- B. Wage rates
- C. Key personnel

V Material
- A. Principal suppliers and delivery dates
- B. Extent of material prefabrication

VI Cost Section
- A. Comparison of estimated and actual costs
- B. Significant relationships

MEET THE AUTHOR

WILLIAM I. McKAY is manager of the estimating department of The Fluor Corporation, Ltd., Los Angeles. He received a physics degree at San Francisco State College and a graduate degree in meteorology at Massachusetts Institute of Technology. McKay was previously a chief estimator for Refinery Engineering Company, Tulsa, and supervising estimator for Bechtel Corporation, San Francisco. He is a registered professional engineer in California.

How to Use This Outline

I. General

A. Scope of work . . . Describe in sufficient detail the scope of work so that persons unfamiliar with the project can visualize its extent. Give the unit type and capacity, its location and the client for whom it was built. Supplemental information such as plot plan, flow sheets and photographs taken during construction should be included. Time is saved by incorporating all of this information in the cost report. It requires many hours to run down these items a year or so after a project has been completed.

B. Type of contract . . . Indicate the type of contract under which the work was performed. One of the following should be listed:

1. Turnkey
2. Cost-plus, a fixed or percentage fee
3. Cost plus a fixed fee with a guaranteed maximum cost (possibly with a participation in any savings by the contractor)
4. Any of the above in conjunction with a guaranteed completion date with a bonus-penalty arrangement

C. Chronology . . . Tabulate the dates for significant periods of the project. These dates should include:

1. Date requested for receipt of bid
2. Date proposal was submitted
3. Date contract was awarded
4. Date engineering was started
5. Date construction was started
6. Date beneficial occupancy was achieved
7. Date construction was completed

In addition, an actual construction schedule should be compiled if the information is available.

II. Specific Conditions

A. Physical features of job . . . Discuss major items which dominated the planning of construction. Tabulate the size, height, and weight of all major equipment. State whether unit utilities were self-contained or were made available at plot limits. Mention the extent of instrumentation, spare equipment, service structures, etc.

B. Site conditions . . . Local site conditions can greatly affect the cost of construction work. It is important that those who use the report are aware of such conditions. Some items of this category are:

1. Soil condition:
   - a. Maximum allowable bearing?
   - b. Piling required?
   - c. Ground water level?
   - d. Shoring necessary? Rock, etc.?
2. Accessibility of site?
3. Working room?
4. How far from nearest railroad siding?
5. Distance from nearest town?
6. Hazardous or non-welding areas?
7. Smoking permitted?
8. Site level and free of overhead and underground obstruction?
9. How far to disposal area for excess excavation?

C. Weather . . . The fickleness of wind and sun has a pronounced effect on costs. A tabulation of weather conditions should be recorded throughout the job. This record should show:

1. Work days lost due to rain, snow, cold, wind or other meteorological conditions
2. Amount of money paid as "show-up" time where no productivity was realized

3. Number of days worked with restricted productivity due to weather

D. Items furnished by client . . . There are often items and services furnished to the contractor during construction, and they should be tabulated. Such items might include:

1. Utilities:
   a. Construction power (voltage?)
   b. Construction water
   c. Construction steam
   d. Construction fuel gas
   e. Construction air
2. Temporary facilities:
   a. Parking area
   b. Railroad siding
   c. Fencing
   d. Field office
   e. Warehouse
   f. Fabrication
   g. Sanitary facilities
3. Construction equipment
4. Security (guard service)
5. Permanent materials
6. Startup personnel and supplies
7. Permits and licenses

III. Methods

A. Temporary facilities . . . Describe all temporary facilities required by the project. Include dimensions of all buildings, temporary utility requirements and size of storage and fabricating areas.

B. Sub-contracts . . . List all categories of the work that were performed under sub-contract. Describe the extent of services provided for sub-contractors in connection with their work.

C. Construction equipment . . . Tabulate construction equipment, showing the capacities and the number of rental months charged to the project by each classification.

D. Erection procedures . . . General methods of construction should be described. This description should include:

1. How excavation was accomplished
2. How concrete was poured
3. How heavy equipment was set:
   a. Gin poles?
   b. Guy derrick?
   c. Mobile crane?
   d. Cribbing and jacking?
4. Was shop-fabricated or field-fabricated pipe used?
5. Other significant features

IV. Labor

A. Labor conditions . . . Field labor is the largest single variable in estimating construction work. Because of the wide variance in labor costs encountered under different conditions, all conditions affecting labor should be tabulated for each job. Typical examples of these variables are:

1. Availability of manpower:
   a. Skilled
   b. Semi-skilled
2. Labor disputes
3. How did productivity compare with other areas?
4. Special union agreements requiring additional men
5. Manpower:
   a. Peak force
   b. Average force
   c. Total man-days
   d. Percent distribution of total man-days by crafts
   e. Turnover rate

B. Wage rates . . .

1. Tabulate, by crafts, wage rates paid
2. Extent of scheduled overtime, if any
3. Overtime premiums
4. Fringe benefits paid:
   a. Travel pay
   b. Subsistance
   c. Other
5. Average hourly wage rate (divide total labor by total man-hours)

C. Key personnel . . . List all supervisory, field engineering and field office personnel assigned to the project. They should be listed by name, title and number of months assigned to the job.

V. Materials

A. Principal suppliers and delivery dates . . . Tabulate this information under the following headings. Do not list minor or bulk materials.

1. Item
2. Supplier
3. Scheduled delivery date
4. Actual delivery date

B. Extent of material prefabrication . . . Indicate how much of the fabrication or assembly of materials was accomplished by the vendor. Such items might include:

1. Vessels:
   a. In one piece or "knocked down"
   b. Internals installed in shop or field
2. Boilers and heaters (package units or field-assembled)
3. Shop or field-fabricated piping
4. Shop or field-fabricated structural steel
5. Shop or field-fabricated reinforcing steel
6. Instrument panel piped and wired in shop or field
7. Transit-mixed or field-mixed concrete

VI. Cost Section

A. Comparison of estimated and actual costs . . . Estimated and actual costs should be tabulated side by side in as complete detail as the accounting records permit. Quantity and unit cost information should be included in this tabulation. This will point out those items under or over-estimated quantity-wise as well as cost-wise when compared with the actual quantities and costs. A suggested form for this presentation is shown in Fig. 1. Do not attempt to compile detailed costs for items that are not significant to the total cost for the project. In the "Material Cost" and "Labor Cost" columns, show only whole dollars and omit cents. Any unusual discrepancies between estimated and actual costs should be explained with footnotes.

B. Significant relationships . . . Certain items of cost are useful when recorded for estimating purposes as a percentage of direct labor, direct material, direct cost, field cost, or total cost. Such items are:

1. Field supervisory and office personnel
2. Small tools
3. Equipment rentals
4. Temporary facilities
5. Payroll taxes and insurance
6. Design engineering
7. Procurement
8. Consumable construction supplies

Other ratios, such as labor/material, might be important. All such information should be expressed.

Accurate cost information and sharp estimating tools are made possible only by starting with a complete and well-defined classification of accounts, as a common base line, and the joint cooperation of all personnel assigned to the project. Remember that you are buying tools with which accurate future estimates can be constructed and costly mistakes avoided, even though it may represent an additional cost to the project. ★ ★ ★

DU PONT *Petroleum Chemicals* NEWS

Number 103 in a series of bulletins for the Petroleum Industry

AUGUST 1960

Du Pont reports on the progress of linear programming

HERBERT O. BAILEY and JACK S. BELLAH, refinery technologists, discuss the programming of a customer's refinery operation.

The purpose of the Du Pont linear programming service is to help refiners look at *both* the forest and the trees – to analyze the economic effect of every processing and blending phase, and from this analysis obtain an over-all view of the economy of a particular refinery's operation.

In one instance, linear programming showed how a company was losing over $1 per barrel by diverting one component to a less profitable alternate use.

In another case, a company learned that it was buying a component at a price considerably above its actual value to them.

Du Pont has now expanded the scope and capabilities of its linear programming service. The past and the future of this service are explored in the statements on this page by Jack S. Bellah and Herbert O. Bailey, Du Pont refinery technologists.

Linear programming up to now by Jack S. Bellah

"In the past two years the many customers who have utilized our linear programming service have found it to be a useful adjunct to their over-all refinery operations and planning.

"On occasion, the analyses they received opened the door for changes which could effect appreciable economies. In other instances, results have verified that the *modus operandi* of the refiner was already at the optimum.

"Du Pont instituted this service with two purposes in mind:

"First, as a study of a customer's actual operations – to develop the over-all economic picture of his gasoline blending operations, putting all factors into their proper economic perspective when maximizing profit. From this, much information can be readily developed on the effect of varying elements of the system.

"Second, where the customer is interested in linear programming as a permanent tool in his own economic studies, a trial run by Du Pont can give him experience on which to base his own choice of programming system. In some cases, Du Pont has helped to train those persons who will make the actual studies, and has continued to suggest ways in which the studies can be broadened into more comprehensive and useful management tools."

The future for linear programming

by Herbert O. Bailey

"We expect to expand the Du Pont linear programming service by introducing more customers to it and by exchanging ideas, concepts and methods with those who have already started using it.

"One new approach is our use of the IBM 704 computer. The larger memory capacity of this machine helps us assist our customers in studying larger and more complex problems, including: maximizing the profit on numerous grades of gasoline; interseasonal storage of gasoline and heating oil components; complete refinery simulation from crude to finished products.

"On the 704 we can, within reasonable limits, incorporate in a single problem the combination of variables that determines:

a) Selection of crude slates.

b) Determination of reforming severity level and tetraethyl lead concentration for minimum cost research and motor octane numbers.

c) Choice of catalytic cracking plant feed stocks.

d) Disposition of butanes among motor gasoline, alkylation or polymerization plant feed stock.

e) Component and finished product production within process capacity limitations, and with all finished products meeting specifications.

f) Size of profitable marketing areas."

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DU PONT *Petroleum Chemicals* NEWS

ATTENTION MARKETERS:

New survey probing motorist buying habits soon to be released

Now in the final stages of compilation is the 1960 Du Pont survey, "Profile of the Motorist". This is the fourth in a series that constitutes the largest such study ever undertaken in the petroleum industry.

Coast-to-coast interviews (4,300) are shedding new light on old questions, such as: gasoline brand preference, loyalty to service stations, the effect of price wars on buying habits, regular-vs-premium grades, and non-petroleum purchases at service stations.

Other areas of particular interest include: the growing use of non-oil company credit cards, vacation use of automobiles, the effect of trading stamps and activities that compete with driving (such as home swimming pools, daytime television).

This study is another example of the marketing services available to Du Pont customers. Results will be available this fall.

Du Pont study shows fewer gasolines cause carburetor icing

Results are now available to marketers and refiners from the *Winter, 1960,* Du Pont Survey of Carburetor Icing.

30 regular grade gasolines, 30 premiums, and 4 super premiums were investigated. Samples were obtained from service stations in various marketing areas, with particular emphasis on regions where carburetor icing has been most prevalent.

Contrasted with results of the 1959 survey, it appears that there was a general decrease in the tendency of motor gasolines to cause carburetor icing:

47% of *regular* gasolines were satisfactory, compared with 35% in 1959.

63% of all *premium* gasolines were satisfactory, compared with 55% in 1959.

Full information on this study – including the comparison with last year – is available from your Petroleum Chemicals Division representative.

Western Regional Manager

E. HEARN SIMPSON, who recently assumed the duties of Western regional manager for Du Pont's Petroleum Chemicals Division, brings more than twenty-four years of petroleum experience to his new position. He succeeds the late Robert F. Harwick.

Mr. Simpson started with Du Pont in 1930 in the sales department of the "Fabrikoid" Division, Newburgh, N. Y., and two years later became a sales correspondent in the Alcohol Division of the Organic Chemicals Department in Wilmington, Del. In 1934 he became a salesman in the same division, where he was concerned with the sale of gasoline antioxidants, oil colors, and alcohol in the Middle West.

From 1943 until 1946 Mr. Simpson was a supply officer in the U. S. Navy. He returned to Du Pont in 1946 as sales manager of the alcohol and camphor section, Petroleum Chemicals Division, and a year later was named assistant sales manager of petroleum additives. In 1950 he was appointed manager in charge of industrial sales for the Petroleum Chemicals Division and the following year was named acting manager of the Eastern Region with headquarters in New York City. In 1952, Mr. Simpson returned to Wilmington as manager of sales of the Petroleum Chemicals Division, a post which has now been discontinued.

A native of Washington, D. C., Mr. Simpson attended public schools in Delaware, Oklahoma, and Colorado, and joined Du Pont following graduation from the University of Denver with a bachelor of science degree in 1930. He is a member of the American Petroleum Institute.

New Du Pont yellow dye is 20% stronger, more soluble

Now you can add yellow color to gasoline and other petroleum products more readily with Du Pont's new Oil Yellow NB. This new dye is 15% to 20% stronger than its predecessor, Oil Yellow N.

Use less dye. With Oil Yellow NB you use less dye to get the same results obtained up till now with Oil Yellow N.

Improved solubility. Another advantage of Oil Yellow NB is its greater solubility in petroleum products. Its approximate solubility, ascertained from test samples, is 4000 mg/100 ml in a test gasoline, compared to approximately 2000 mg/100 ml for Oil Yellow N.

Now available. Deliveries of Oil Yellow NB are now being made from our plant at Carneys Point, N. J., and from warehouses across the United States. The dye is shipped in standard 100-lb.-net packages.

With Oil Yellow NB you can add the advantage of *faster dyeing* to that of *lower dye requirements.* For additional information and samples, contact your Du Pont representative.

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Du Pont Tetraethyl Lead and other Petroleum Additives

OVER

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

A-15405

Printed in U.S.A.

DR. J. M. MARCHELLO, *Oklahoma State University*

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PETRO/CHEM

ALGEBRA | *part 3*

MATHEMATICAL treatment of engineering problems and the methods of solving process and design problems are the objectives of this series of articles. In Article 2 the general characteristics of algebraic equations were discussed and some of the methods for solving equations were presented. The object of this article is to present the Fundamental Theorem of Algebra and to introduce some of the elementary notions of complex variables.

D. The Fundamental Theorem of Algebra

Every polynomial of degree n,

$$f(x) = x^n + a_{n-1}x^{n-1} + \ldots + a_1x + a_o \quad . \quad . \quad . \quad . \quad (1)$$

can be factored into the product of exactly n factors,

$$f(x) = (x - \alpha_1)(x - \alpha_2) \ldots (x - \alpha_n) \quad . \quad (2)$$

where $\alpha_1, \alpha_2, \ldots, \alpha_n$ are complex numbers and are called the roots of the equation $f(x) = 0$.

As an example, consider the polynomial

$$f(x) = x^4 - 1 \quad . \quad . \quad . \quad . \quad . \quad (3)$$

which factors into the form

$$f(x) = (x - 1)(x - i)(x + i)(x + 1) \quad . \quad (4)$$

where $i = \sqrt{-1}$. The roots of equation (3) are then $(\alpha_1 = 1)$, $(\alpha_2 = i)$, $(\alpha_3 = -i)$ and $(\alpha_4 = -1)$. The fact that these quantities are roots of equation (3) when $f(x) = 0$ may be checked by substitution.

As a further example of this important theorem consider the quadratic equation

$$ax^2 + bx + c = 0 \quad . \quad . \quad . \quad . \quad (5)$$

the roots of equation (5) are given by the familiar expressions:

$$\alpha_1 = \frac{1}{2a}\left(-b + \sqrt{b^2 - 4ac}\right) \quad . \quad (6a)$$

$$\alpha_2 = \frac{1}{2a}\left(-b - \sqrt{b^2 - 4ac}\right) \quad . \quad (6b)$$

when the coefficients a, b and c are real numbers the nature of the roots is determined by the discriminant, $b^2 - 4ac$. The various possibilities are:

- If $(b^2 - 4ac)$ is positive, the roots are real and unequal.
- If $(b^2 - 4ac)$ is zero, the roots are real and equal.
- If $(b^2 - 4ac)$ is negative, the roots are conjugate imaginary.

E. Complex Numbers

In general an algebraic number is any number x, real or complex, that satisfies some algebraic equation of the form

$$a_nx^n + a_{n-1}x^{n-1} + \ldots + a_1x + a_o = 0 \quad (7)$$

where $n \geqslant 1$, $a_n \neq 0$ and the coefficients a_k are integers.

From an elementary standpoint the process which first requires the use of complex numbers is that of solving quadratic equations. A simple equation such as

$$x^2 + 1 = 0 \quad . \quad . \quad . \quad . \quad (8)$$

has no real solution, since the square of any real number is never negative. In order to make equation (8) solvable it is necessary to introduce an imaginary unit, i, defined by the expression

$$i^2 = -1 \quad . \quad . \quad . \quad . \quad (9)$$

Using this imaginary unit to add and multiply with ordinary real numbers, it is possible to build up the set of complex numbers. The set of complex numbers can be represented by the symbol $(c + id)$, where c and d are any two real numbers. The number is then said to have a real part c and an imaginary part d.

The field of real numbers is included as a subfield in the more general field of complex numbers. For example, the complex number $(a + i0)$ is a real number. On the other hand, the number $(0 + ib)$ is a pure imaginary number.

Try your hand at Problem 5. Solution will be published next month. ➠

PROBLEM 5

Punching Machine Performance

In the modification of some existing process equipment it will be necessary for the fabrication shop to punch a number of 2½-in. holes in ½-in. steel plate. A punching machine is available, however, there is a question of whether it has sufficient capacity for the job. Having this fabrication done elsewhere will result in a considerable expenditure of time and money.

The available punching machine is of rugged design and has been used for a variety of jobs in the past. The flywheel is driven at 220 rpm. The work of punching a hole is supplied by the flywheel of the machine and each operation of punching a hole causes a momentary decrease in its speed. The flywheel is of a hollow cylinder design and made of cast iron 4½ in. wide with an outside diameter of 3 ft and an inside diameter of 2 ft. Assume that the density of cast iron is 450 lb per cu ft and that the ultimate shearing strength of the steel plate to be punched is 60,000 psi.

Can the machine do the job?

Solution to July's Problems:

Problem 3.

A reaction which occurs in hydrocarbon combustion systems ranging from refinery cracking furnaces to rocket engines is the water gas reaction.

$$CO + H_2O \rightleftarrows CO_2 + H_2 \quad . \quad . \quad (3\text{-}1)$$

$$\log_{10} K_p = 1 = \log_{10} \left(\frac{P_{CO_2} P_{H_2}}{P_{CO}\ P_{H_2O}} \right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3\text{-}2)$$

For an ideal gas mixture the mole fraction of a component is equal to its partial pressure divided by the total pressure, then

$$\log_{10} \left(\frac{y_{CO} y_{H_2}}{y_{CO} y_{H_2O}} \right) = 1 \quad . \quad . \quad (3\text{-}3)$$

Taking the anti-log of equation (3-3)

$$\frac{y_{CO_2} y_{H_2}}{y_{CO_2} y_{H_2O}} = 10 \quad . \quad . \quad . \quad (3\text{-}4)$$

Designating the number of moles of H_2 at equilibrium by n, the amounts of the other components are:

$H_2O : 2 - n$
$CO : 1 - n$
$CO_2 : 1 + n$

Total moles $= n + 2 - n + 1 - n + 1 + n = 4$
In terms of mole fractions,

$$y_{H_2} = \frac{n}{4} \quad . \quad . \quad . \quad (3\text{-}5a)$$

$$y_{CO} = \frac{1 - n}{4} \quad . \quad . \quad . \quad (3\text{-}5b)$$

$$y_{CO_2} = \frac{1 + n}{4} \quad . \quad . \quad . \quad (3\text{-}5c)$$

$$y_{H_2O} = \frac{2 - n}{4} \quad . \quad . \quad . \quad (3\text{-}5d)$$

Substituting equation (3-5) into (3-4)

$$\frac{(1 + n)\ (n)}{(2 - n)\ (1 - n)} = 10 \quad . \quad . \quad (3\text{-}6)$$

rearranging equation (3-6)

$$n^2 - 3.12n + 2.22 = 0 \quad . \quad . \quad (3\text{-}7)$$

The solutions to equation (3-7) are given by the quadratic formula:

$$n = \tfrac{1}{2}(3.12 \pm \sqrt{9.75 - 8.88}) \quad . \quad (3\text{-}8a)$$

$$n = 1.10 \text{ moles} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3\text{-}8b)$$

$$n = 2.02 \text{ moles} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3\text{-}8c)$$

Any hydrogen which is formed must come from the steam. Equation (3-5d) indicates that n cannot be greater than 2.00. Then we have the condition:

$$0 \leqslant n \leqslant 2$$

The solution which is physically realistic is equation (3-8b). The moles of steam decomposed at equilibrium is 1.1 or 55 percent of the initial amount present.

Problem 4.

The vapor-liquid equilibrium K values of the three components depend upon the temperature, which is to be determined. A trial and error procedure is convenient since the K values cannot be readily expressed as simple functions of temperature.

The equations which govern the physical situation are:

$$y_b = K_b x_b = 0.2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4\text{-}1)$$

$$y_t = K_t x_t = 0.3 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4\text{-}2)$$

$$y_x = K_x x_x = 0.5 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4\text{-}3)$$

$$x_b + x_t + x_x = 1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4\text{-}4)$$

Combining these equations together gives

$$\frac{0.2}{K_b} + \frac{0.3}{K_t} + \frac{0.5}{K_x} = 1 \quad . \quad . \quad (4\text{-}5)$$

Each of the K values are dependent on temperature so that in principle, there are three functional relationships of the form:

$$K_i = f_i(t) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4\text{-}6)$$

These three relations, together with equation (4-5), represent a system of four equations and four unknowns to be solved simultaneously.

The usual trial and error procedure for this type of problem involves: assuming a temperature; determining the K values; and, checking the assumption by substitution into equation (4-5). If the left side of equation (4-5) does not equal unity a new temperature is assumed.

At the conditions existing in this problem, the vapors are essentially ideal and vapor pressure data can be used to determine the K values. An assumed temperature of 263 F gives $K_b = 3.42$, $K_t = 1.55$ and $K_x = 0.672$. The check is sufficiently close to consider 263 F the dew point of the mixture.

CLIP/FILE
PETRO/CHEM

PETRO/CHEM new literature

Accessories and special control equipment . . . including break-glass switches, control stations for mechanically held switches and relays, relay panel for gas valves, engine generator isolating switches, marine duty transfer switches, and phase sequence correctors . . . are detailed in Catalog 57-S7. *Automatic Switch Company.*
Circle number (60) on reply card.

Alliflex stainless steel hose . . . for handling high temperature, high pressure, and highly corrosive media . . . is explained in Stainless Steel Data Sheet 562. *Allied Metal Hose Company.*
Circle number (61) on reply card.

Alumi-Spra . . . new corrosion and scale-resisting coating which permits use of low cost ferritic alloy steels instead of the more expensive austenitic stainless steels . . . is explained in brochure. *Chicago Metallizing Corporation.*
Circle number (62) on reply card.

Butterfly valves . . . for control of large volumes of liquids or gases . . . are discussed in folder which supplements Catalog No. 307. *Mason-Neilan, division of Worthington Corporation.*
Circle number (63) on reply card.

Cleaning problems . . . in the chemical industries defy cataloging, but new booklet "Maintenance Cleaning in the Chemical Industry" simplifies the diagnosis and suggests treatments. *Oakite Products, Inc.*
Circle number (64) on reply card.

Components . . . for control of gas or liquid over a temperature range from minus 320 to 1500 F and pressures to over 3500 psig . . . are covered in new catalog which describes fuel control systems, pneumatic and electrical valves, actuators, air motors, and thermostats. *AiResearch Manufacturing Company.*
Circle number (65) on reply card.

Condensers . . . for condensing steam and removing air and other non-condensable gases . . . are listed in Bulletin Supplement 5AA-E. *Schutte and Koerting Company.*
Circle number (66) on reply card.

Cranes . . . truck mounted and floor models . . . are described in Catalog W-102, which gives specifications of various types in capacities of from 500 to 4000 lb. *H. S. Watson Company.*
Circle number (67) on reply card.

Double cushioned electric check valve . . . which does not open until the pump comes up to speed . . . is described in Bulletin W-10A. When the valve is 95 percent closed, the pump is automatically shut down, eliminating the hammer and shock in closing. *Golden-Anderson Valve Specialty Company.*
Circle number (68) on reply card.

Econo-Wells . . . stainless steel forged thermowells that are available for use with thermocouples, test instruments, and bi-metallic thermometers . . . are listed and described in Bulletin TT-307. *Trinity Equipment Corporation.*
Circle number (69) on reply card.

Gas-combustion and control equipment . . . is described in new catalog, which details every type of burner, mixer, pilot, regulator, blower, valve, and accessory made by this manufacturer. *Bryant Industrial Products Corporation.*
Circle number (70) on reply card.

Heat exchangers . . . the new 3-in. low pressure double pipe design . . . are discussed in Bulletin 110. *Brown Fintube Company.*
Circle number (71) on reply card.

High alloy castings . . . are subject of "Technical Publications List," which summarizes technical literature resulting from the Institute's informational program. *Alloy Casting Institute.*
Circle number (72) on reply card.

High-capacity alarm/control system . . . providing an inexpensive method of locating faults at unattended remote operations and controlling "on-off" functions remotely . . . is explained in Bulletin ECM 119. *General Electric Communication Products Department.*
Circle number (73) on reply card.

High temperature water systems . . . designed to utilize low-cost conventional water tube steam boilers or forced circulation boilers . . . are discussed in Bulletin G-92. *Babcock & Wilcox.*
Circle number (74) on reply card.

Indicating pneumatic controllers . . . are subject of Bulletin DMO58 that introduces the new Series 624 with A/D control unit. Specifications are given and models listed for controlling pressure, vacuum, liquid level, flow, temperature, and humidity. *The Bristol Company.*
Circle number (75) on reply card.

"Isotemp" . . . packaged centrifugal air compressor line . . . is described in 20-page Bulletin 175 which gives detailed engineering data that permits approximating horsepower requirements for various applications. *Clark Bros. Co.*
Circle number (76) on reply card.

Mechanipak seals . . . for pressure up to 150 psi . . . are subject of Bulletin ADO50, which outlines temperature, pressure, shaft speed, and other critical operating information necessary when selecting or utilizing mechanical sealing devices. *Garlock, Inc.*
Circle number (77) on reply card.

Model P transmitter . . . an inexpensive yet rugged instrument capable of measuring pressures as high as 250 psi or ranges from as low as 0 to 100 in. of water . . . is described in Bulletin P-36-1. *Conoflow Corporation.*
Circle number (78) on reply card.

P-K Paul control valves . . . of unique Venturi-ball design . . . are subject of Catalog GV-101, which presents engineering, specification, and purchasing information on the complete line of cast, barstock, and special valves. *General Kinetics Corporation.*
Circle number (79) on reply card.

Penton Buyer's Guide . . . lists all current producers of Penton, applicable as corrosion-resistant lining for tanks. *Hercules Powder Company.*
Circle number (80) on reply card.

Refractories data brochure . . . summarizes the many types and classes of refractories used in chemical and petrochemical industries. Included are many brands which have been proved in service over the years and more recent or comparatively new brands. *Harbison-Walker Refractories Co.*
Circle number (100) on reply card.

"Re-thinking Thermal Insulation" . . . is guide to best use of thermal insulating materials under the changing conditions of modern industry. It emphasizes the "economic thickness" approach to specification, which enables management and engineers to determine the point at which insulation gives the greatest financial return for its cost, considering both operating and capital savings. *National Insulation Manufacturers Association.*
Circle number (101) on reply card.

Safety-relief valves . . . are detailed in Catalog FE-138, which gives useful sizing information, capacity tables, weights and dimensions, and application data. *Farris Engineering Corporation.*
Circle number (102) on reply card.

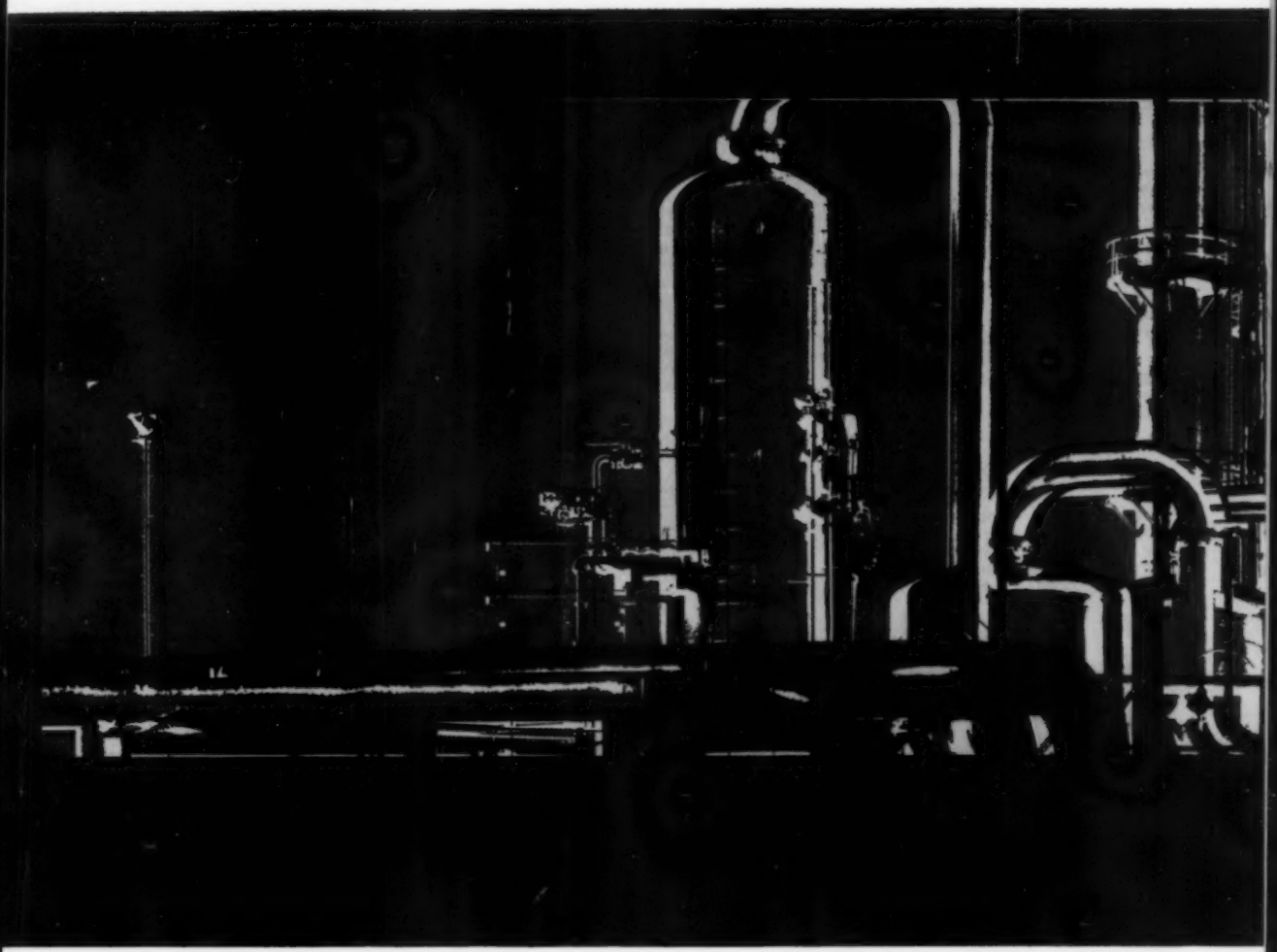
Seamless-type welding fittings . . . are illustrated in Bulletin 60-C which gives size ranges . . . applications. *Midwest Piping Company, Inc.*
Circle number (103) on reply card.

Steel tubing . . . produced by the first mill in the West . . . is illustrated and discussed in Catalog 60. *Pacific Tube Company.*
Circle number (104) on reply card.

Strubing . . . seamless light-wall tube that is processed in strip form and rolled up for compact shipment . . . is discussed in new brochure. *Wolverine Tube, Division of Calumet & Hecla, Inc.*
Circle number (105) on reply card.

"Twin" Circuit Breaker Load Centers . . . are detailed in Bulletin GEA-7071, which tells of 15 new 150 and 200-amp units. *General Electric Company.*
Circle number (106) on reply card.

Vest Pocket Guide to Better Welds . . . contains a wealth of information useful to engineers, shop supervisors, foremen, technicians, draftsmen, instructors, and students, as well as to welders. *Hobart Brothers Company.*
Circle number (107) on reply card.



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Carbon, ½ Mo	5 Cr, ½ Mo, 1½ Si	18-8
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1¼ Cr, ½ Mo	8 Cr, ½ Mo	18-8 Cb
2 Cr, ½ Mo	8 Cr, 1 Mo	18-8 Mo
2¼ Cr, 1 Mo	9 Cr, 1 Mo	25-20
2½ Cr, ½ Mo, ¾ Si	12 Cr	3½ Ni
3 Cr, 1 Mo	12 Cr, Al	5 Ni

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PETRO/CHEM new equipment

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Answer

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Circle number (41) on reply card.

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Jet-Mogenizer combines forces of impact, attrition, turbulence, and ultrasonic cavitation to deliver optimum homogenization.

To accomplish this, the spline pattern in all three stages has been deliberately thrown out of register to convert a constant rhythmic flow into sustained eddying pressure impulses, thus impeding easy access of the processed material and preventing it from shooting through at high velocity insufficiently processed.

Four sizes are available, with production ranges from 100 to 500 gal per hr. *Buschman Products Inc.*

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New V-Belt Line

A new and complete line of matched V-belts has been introduced for the hydrocarbon process industry.

Three independent matching operations are performed on Crown V-belts between factory and consumer to assure a match which exceeds standard API specifications by a significant margin. *Skinner Brothers Company.*

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Fractionator Reflux Control

Honeywell FRAC (fractionator reflux analog computer) unit maintains a steady-state heat and material balance in fractionators by measuring the internal reflux rate and regulating the external reflux rate accordingly, hence giving more economical and efficient column operation . . . increased production of uniform, on-spec products. *Minneapolis-Honeywell Regulator Company.*

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Explosion-Proof Hand Lamp

Type EVH106 hand lamp is explosion-proof and weather-resistant . . . weighs only 4½ lb. All parts are designed to withstand rough usage. Terminal housing encloses three pressure connector terminals, including grounding terminal. Molded-in conductors between lamp receptacle and pressure connectors ensure trouble-free internal fixture wiring. Cords can be changed without using soldering iron. Swivel-type hook on the guard holds lamp in position for use in tight spots, leaving both hands free to work. *Crouse-Hinds Company.*

Circle number (45) on reply card.

Solid Wedge Disc Gate Valves

New Flex Gate valves have flexible wedge disc. Gates do not stick closed, which means minimum scrape and wear of the disc and seats. The flexible wedge disc also compensates for minor misalignment of seats due to pipeline deflections. Working pressure of the 150-lb valve ranges from 40 psi at 1000 F to 275 psi at 100 F. The 300-lb valve has a range from 85 to 720 psi at a similar temperature range. *Crane Co.*

Circle number (46) on reply card.

Non-Toxic Corrosion Inhibitor

Dearborn 860 can be used in both open recirculating and once-through cooling systems where toxic contaminants such as chromate are not permitted by state and local regulations. It provides corrosion protection comparable to that obtained with chromate-polyphosphate combinations, and much superior to that realized with ordinary polyphosphates. *Dearborn Chemical Company.*

Circle number (47) on reply card.

(Continued on C-56)

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HELPFUL WATER CONDITIONING DATA FROM BETZ

SLIME CONTROL WITH CHLORINE

Judicious use of chlorine and the supplemental use of other biocides will extend cooling tower life

A RECENT SURVEY of open recirculating cooling water systems has revealed that more than ninety percent of these systems require treatment for prevention of biological fouling in order to avoid loss in heat transfer and to prevent accelerated corrosion. The survey further revealed that in the majority of these systems chlorine is used for slime control or is supplemented by a non-oxidizing type biocide. Chlorine is used widely because it is effective, fast acting and economical. The increased trend toward the supplemental use of non-oxidizing biocides is due to the adverse effects chlorine has on cooling tower wood.

Chlorination

There is ample evidence that chemical attack renders the wood more susceptible to biological attack. It has been definitely established that excessive chlorination will cause delignification of cooling tower wood. Delignification also occurs when excessive alkalinity is maintained in the circulating water. The combination of excessive alkalinity and chlorine will produce severe chemical attack. Both chemical and biological attack have been more prevalent in towers that use chlorine alone for prevention of slime. Conversely, the incidence and frequency of chemical and biological attack has been at a minimum in systems that use non-oxidizing biocides alone for slime control.

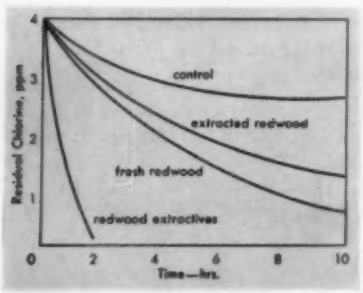

Figure 1—Reaction rate of chlorine with redwood and redwood extractives.

It may seem contradictory that an effective slime control agent such as chlorine pre-disposes wood to biological attack. Figure 1 shows the rate of reaction of chlorine with redwood and redwood extractives. In addition to reacting with the lignin components of the wood, chlorine will react with the natural extractives. The rapid removal or destruction of nature's toxicants from the wood renders the wood more susceptible to biological attack.

Undoubtedly, many of the systems that have shown rapid or excessive attack from the use of chlorine have lacked adequate control of chlorination. In many of these cases, the chlorine residual has been improperly determined, determined at the wrong point for proper control, not checked frequently enough or neglected entirely. In the majority of the systems using chlorine for slime control, the chlorine residual is checked (as it should be) in the water returning to the tower *not after the water cascades through the tower*. The water in passing through the tower will have its chlorine residual decreased to very low values or depleted entirely. The reduction in chlorine residual occurs partially due to aeration but mainly through reaction with the wood. Where attempts have been made to control chlorine residuals after the water has passed through the tower, excessive chlorine residuals have been permitted to contact the wood and accelerated chemical attack has been the result.

In instances where intermittent chlorination has been practiced, initially the duration of the chlorination period and the rate of chlorination may have been established properly by testing for the chlorine residual. However, all too often, after initially establishing the rate and duration, infrequent or no further testing for chlorine residual is made. Since the chlorine demand of most circulating waters will vary, this practice has led alternately to low residuals and poor slime control or to high residuals and excessive attack of the wood.

While the adverse effects of chlorine on cooling tower wood have been established, it has been apparent that chlorination can be used judiciously and effectively, particularly if supplemented by non-oxidizing type biocide. The chemical attack of cooling tower wood can be held to a minimum by avoiding chlorine residuals greater than 1.0 ppm and preferably by controlling residuals in the range of 0.3 to 0.5 ppm. The pH of the circulating water has an important bearing. Where chlorination is practiced, it is essential that a pH greater than 8.0 be avoided and preferably the pH be maintained in a range of 6.0-7.0.

Non-oxidizing Biocides

The prevalence of biological attack of cooling tower wood in systems using chlorination has led to the conclusion that chemical attack predisposes the wood to biological attack. In cases where carefully controlled chlorination is practiced and chemical attack of the wood surfaces is low, studies have been conducted to check the incidence of fungi on the surfaces of the wood and in the subsurface sections. Microtome sections of the wood, such as that shown in Figure 2, reveal a high incidence of fungi in the wood from the fill and plenum areas of the tower. These studies indicate that chlorination alone is not effective in controlling the organisms responsible for attack of wood. The judicious use of chlorination requires low residuals be maintained. As the water cascades through the tower, these residuals are depleted. The air-borne organisms therefore can and do accumulate

Figure 2—Fungus hyphae growing through wood cells.

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readily on the surfaces of the wood and grow and develop in the subsurface sections. Similar studies conducted for systems that use non-oxidizing biocides alone for slime control show that the incidence of fungi on the wood surfaces is negligible. Since these biocides do not react with the wood, they are able to penetrate the wood surfaces and effectively control the causal organisms. Accordingly, the supplemental use of non-oxidizing biocides is necessary where chlorination is practiced to assure maximum tower life.

One other shortcoming of chlorination has been noted in systems that have large tower sumps wherein the water remains relatively stagnant. Small chlorine residuals do not carry down into the lower depths of the tower sump. Muck and debris accumulate in these areas and provide ample food for growth and development of microorganisms.

	Bacterial Counts			Fungi
Sampling Point	Total	Spore	Sulfate Reducing	—
Circulating water	5	1	0	1
tower sump	2,900,000	63	5	10
Circulating water	6	1	0	0
tower sump	5,600,000	910	2	100

(Counts—no. per ml.)

Table I

residual will be difficult. The supplemental use of non-oxidizing biocides which are not affected by these contaminants will simplify control. In cases where the chlorine demand is continuously high, the economic advantage of chlorine can disappear and the use of alone does not accomplish this purpose, the use of non-oxidizing biocides is required. The added cost for biocides should be charged partially to slime control, and partially to preventive maintenance to lower costs for tower repairs and assure longer tower life.

AND NON-OXIDIZING BIOCIDES

Chemical attack showing ridged and fibrillated wood surface.

Table I shows the microbiological populations for samples taken of the circulating water and from the lower depths of the tower sump. In addition to the high bacteria counts, sulfate-reducing bacteria and fungi were present. Where chlorination is practiced, particularly on an intermittent basis, these areas serve as a point of inoculation. The supplemental use of non-oxidizing biocides will serve to eliminate this point of infection.

In systems where the chlorine demand of the water varies widely due to organic matter present in the makeup, from periodic process contamination, or from changes in direction of the wind carrying air-borne contaminants such as hydrogen sulfide, maintaining the desired chlorine non-oxidizing biocides on a continuous basis would be justified.

Where the cooling water system is relatively small or where there is only infrequent need for slime control agents, it is convenient to employ the non-oxidizing biocides alone. These materials are available in liquid, powder or briquette form and do not require special feeding facilities. The investment for chlorine feeding equipment and the maintenance costs for such equipment would not be justified. In addition, the application of the non-oxidizing biocides does not require elaborate feeding equipment or rigid control, and the cost of application is therefore negligible.

The choice of chlorine for control of slime formation in large cooling water systems is a valid one. However, the application of chlorine must be controlled carefully to avoid adverse effects on wood. It should be realized that where chlorination alone is used, the complete microbiological problem of the cooling water system is not controlled. Normally, slime control is associated with the need to assure maximum heat transfer and to minimize corrosion. *To this should be added the need to protect cooling tower wood.* Since chlorination

Biocides vary in the rapidity of their action and must be selected with a knowledge of the retention time of the system, as well as for compatibility with the corrosion control treatment and numerous other factors. Biocides must be specific for the organisms responsible for attack of cooling tower wood and must exhibit a broad spectrum of biological activity to properly control slime. Research on microbiological problems by Betz Laboratories has resulted in the development of effective and economical biocides. A study of your microbiological problem will entail no obligation. Why not contact a Betz Engineer today? Write, too, for a copy of Bulletin 605 which presents a comprehensive review on protection of cooling tower wood.

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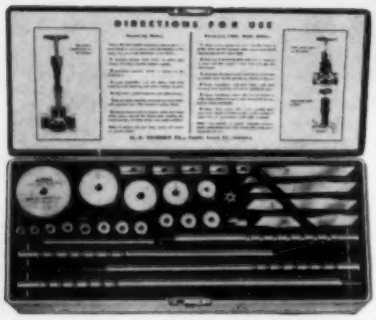

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Cutters operating under screw feed, leave worn, scored seats glass-smooth, level, absolutely accurate and tight.

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4160-V Circuit Breakers

New 4160-v equipment incorporates completely new design from the ground up. Has closed-door drawout and indication of breaker position in compartment, stored-energy closing, ironless blowout, faster closing of contacts and faster interruptions of faults, smaller size and floor area, low center of gravity, and vastly increased accessibility from the compartment front for installation ease and maintenance and service. *I-T-E Circuit Breaker Company.*

Circle number (49) on reply card.

Converter for Magnetic Tape

New IBM 7765 converter transfers data from punched paper tape to magnetic tape. Companies transmitting data with paper tape devices thus can achieve computer input at several times the speed of the fastest direct paper tape input. Features include thorough error-checking and no special air conditioning requirements. Unit needs only a 115-v power connection, and no interconnection with other computer units. *International Business Machines Corporation.*

Circle number (50) on reply card.

Control Stations

Line of pneumatic control stations for "bumpless" transfer between automatic and manual operation as well as for set point loading has been developed to operate with Republic's Vector Series instruments and controls. *Republic Flow Meters Company, Subsidiary of Rockwell Manufacturing Company.*

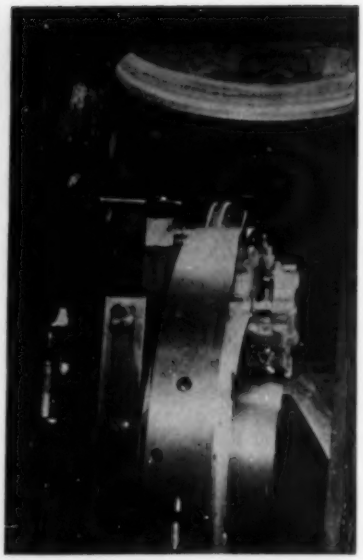
Circle number (51) on reply card.

Stabilizer-Dispersant

Nalco 262, new chemical stabilizer-dispersant, reduces or eliminates potential deposit-forming materials that foul heat exchangers, furnaces, reboilers, and distillation columns. The hydrocarbon soluble additive is injected into naphtha and gas oil streams ahead of the point where fouling occurs. *Nalco Chemical Company.*

Circle number (52) on reply card.

(Continued on C-61)



...Refinish Crank-Pins ...In Place!

- Accurate High Quality Maintenance And Machine Work

The small engine crank pictured above was restored in close quarters without dismantling engine. Our portable machines can solve your problems and save you money. Crank pins from 5½" through 20" in diameter accurately refinished in place at great saving in cost. **Let us help you minimize down time.**

Worn and damaged flywheel fits refinished in place.

In our shop crankshafts of any size or type completely refinished. Shafts straightened and broken shafts successfully repaired.

Most modern methods used in rebabbitting and machining engine and turbine bearings.

All types of heavy power plant equipment serviced with special attention given to emergency repairs.

Additional information furnished without obligation.

WASHINGTON IRON WORKS, INC.
Established 1876
SHERMAN, TEXAS
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Performance makes the world of difference

Fig. 6003—Steel gate valve for 600 W.P. Outside screw rising stem and yoke. Bolted flanged bonnet. Flanged ends.

Fig. 3061A—Steel horizontal swing check valve for 300 W.P. Heavily bolted flanged cap. Full unimpeded flow through when wide open.

Fig. 3058—Carbon steel, screwed end lubricated plug valve. ASA 300 pounds. Screwed gland type, wrench operated.

Fig. 2207G — Semi-steel, flanged end, lubricated plug valve for 200 pounds W.O.G. Bolted gland type. Worm gear operated.

In Powell's complete line of valves are STEEL valves for handling fluids in refineries, petrochemical plants and petroleum storage facilities all over the world.

For 100 years Powell valves have served the vital lifelines of the oil industry. Today, the Powell line includes all types of steel, bronze, iron and corrosion resistant valves in sizes to meet every flow control requirement of the wide-spread petroleum world.

Powell can quickly supply all your valve needs and help solve your valve problems. Contact your nearby Powell distributor. (There's one in all major cities.) Or write directly to the Wm. Powell Company.

Powell . . . world's largest family of valves

THE WM. POWELL COMPANY • DEPENDABLE VALVES SINCE 1846 • CINCINNATI 22, OHIO

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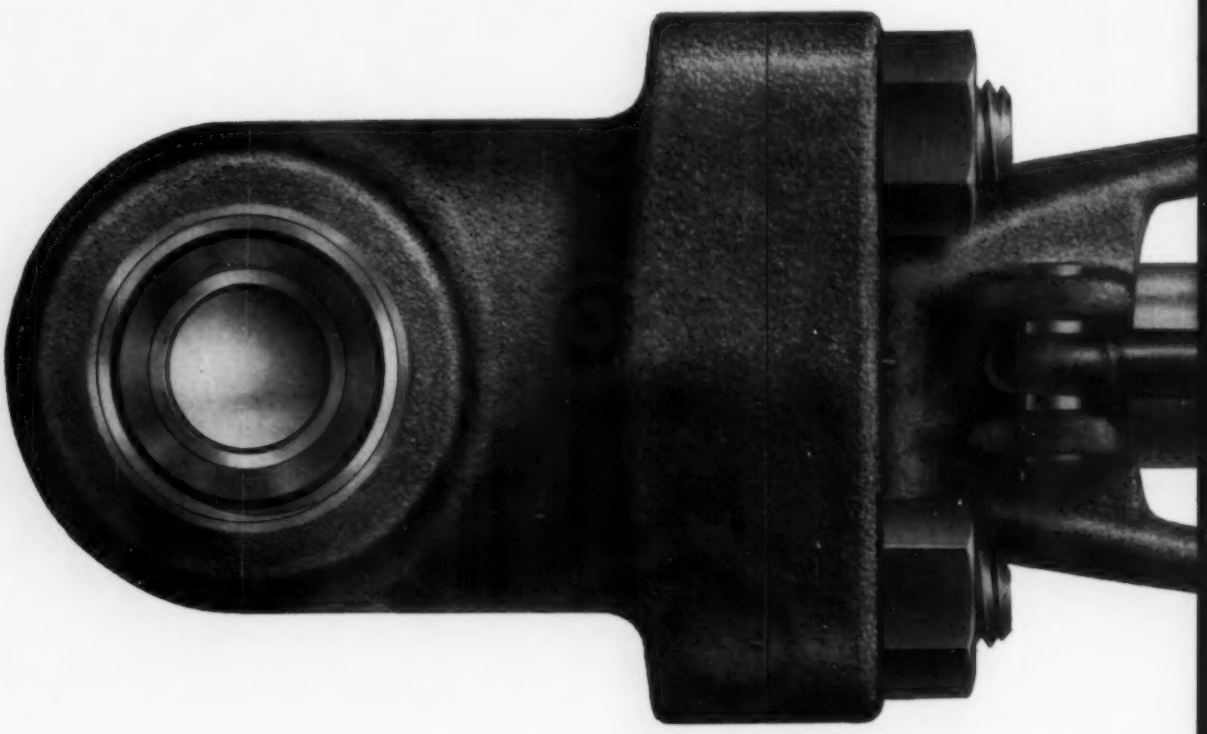
DIRECTION '70

. . . a fast-moving program of planned expansion, product development, and streamlined distribution to help our customers meet the competitive challenges of the Sixties.

COMPLETELY



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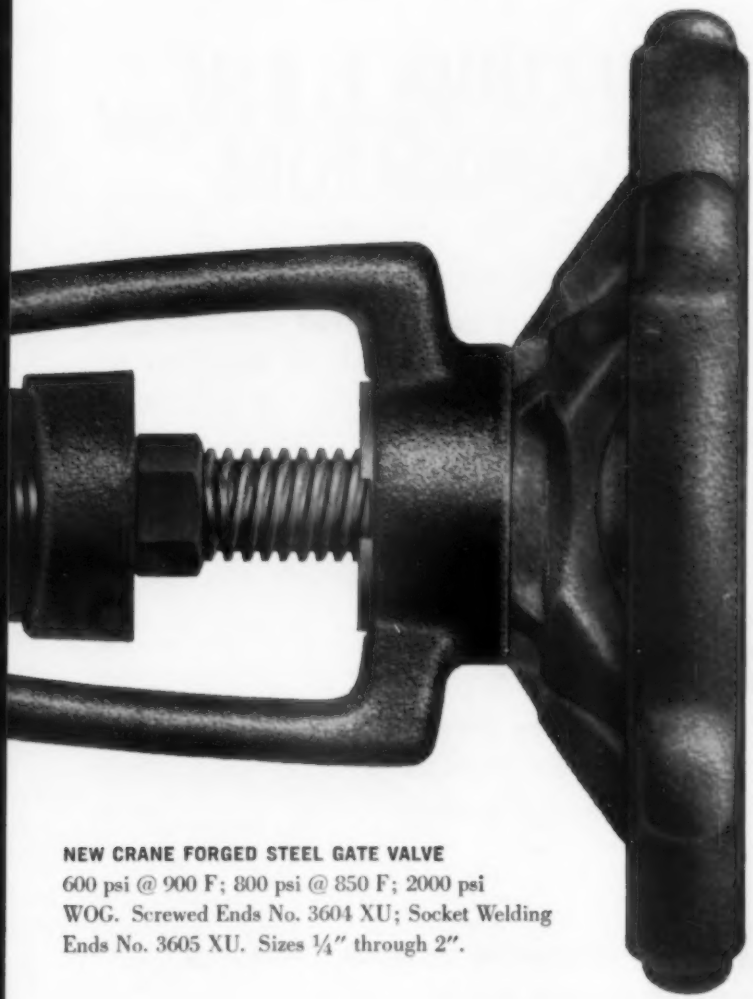
ADVERTISED PRODUCTS, SEE READER SERVICE CARD

REDESIGNED!

THE NEW SMALL FORGED STEEL GATE VALVE



NEW CRANE FORGED STEEL GATE VALVE
600 psi @ 900 F; 800 psi @ 850 F; 2000 psi WOG. Screwed Ends No. 3604 XU; Socket Welding Ends No. 3605 XU. Sizes ¼" through 2".

This is a whole new valve, not just one with a new feature added. This redesign incorporates all the features you told us you wanted plus a few others we know will make this valve a better buy in terms of longer service life, less maintenance, easier and faster servicing.

Like the new "bow-leg" yoke, which for the first time gives you plenty of hand room for easy stuffing box maintenance. And like the long-life braided asbestos packing, with Inconel wire insert. The "universal" trim that can be used for either oil or steam, eliminating many of your stocking problems. The spiral wound stainless steel bonnet gasket with asbestos filler, made blowout-proof with a male-female joint.

But what we really want you to remember, more than any single feature, is that this Crane valve is the newest—all new—valve on the market . . . well worth considering when you need small, high-pressure steel gate valves. We'd like you to compare this new valve with any other comparable valve feature for feature.

Your local Crane distributor has technical literature and a complete selection of these valves right in stock. Call him on small steel gates. In fact, he's your best bet to call no matter what valve you want because he carries the broadest line of quality valves in the world.

CRANE®

CRANE CO., INDUSTRIAL PRODUCTS GROUP
4100 S. KEDZIE AVE. • CHICAGO 32, ILL.
VALVES • ELECTRONIC CONTROLS • PIPING
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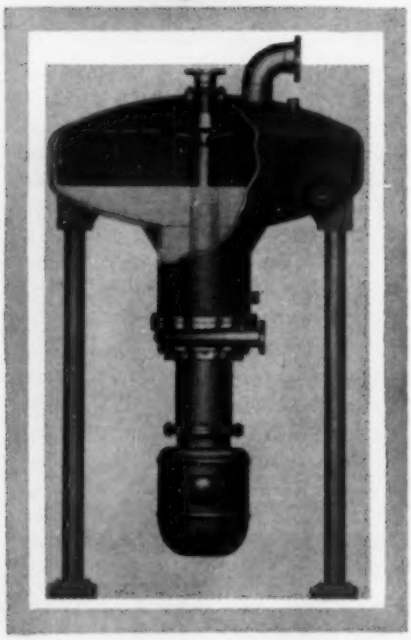
STRIPPING
FOAMING SOLUTIONS

STRATCO

VACUUM FLASH EVAPORATORS



These are but a few examples of the services in which **STRATCO** Flash Evaporators are being used. If you have a problem involving removal of relatively small amounts of volatiles from higher boiling point liquids, a **STRATCO** may be the answer.

Stratco
Flash
Evaporators feature:

. . . enormous liquid surface area exposure

. . . extremely small liquid particle size

. . . highly energized liquid particles.

STRATFORD ENGINEERING CORPORATION

PETROLEUM REFINING ENGINEERS

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D. D. Foster Co., Pittsburgh, Pa.
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Lester Oberholtz, Los Angeles
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for LEAKPROOF PRESSURE-TITE Connections...

TiteSeal
SEALING COMPOUNDS

Heat and vibration-proof, non-solvent, will not shrink, crack or crumble. Makes all assemblies leak-proof and pressure-tight. Prevents rust, corrosion and joint seizure.

7 BASIC BLENDS

LIQUID WRENCH

LOOSENS RUSTED BOLTS

A powerful blend of fast-acting solvents that literally "melt the rust away" —safe on all metals and alloys.

RADIATOR SPECIALTY CO.
CHARLOTTE, N. C.

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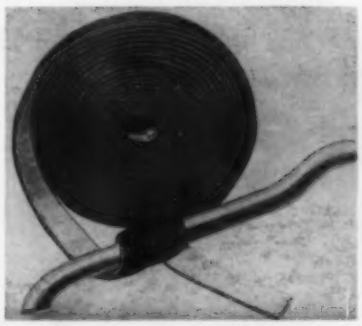
OIL INDUSTRY

Thermocouples
Compensating leads
Resistance thermometers

in many forms specially suited to individual working conditions.

Equipment (Continued)



Wrap-On Pipe Insulation

Insutape, a wrap-on asbestos insulation that is both flameproof and weatherproof, is especially adaptable to difficult application conditions — under close clearance conditions, and for bent or curved instrument lines and pipe. *Union Asbestos & Rubber Co.*

Circle number (53) on reply card.

Silica-Magnesia Catalyst

Davison SM-30, new stabilized silica-magnesia catalyst for petroleum fluid cracking units, contains approximately 28 percent magnesium oxide. Compared with 13 percent silica-alumina catalyst, the new product can be expected to give higher yields of gasoline and furnace oil; lower yields of coke, light gases, and residual fuel, and higher effective activity maintenance. It has the thermal stability and regenerability required by current fluid catalytic cracking units. *Davison Chemical Division, W. R. Grace & Co.*

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Dewpoint Recorder

The W-C Dewpoint Recorder automatically and continuously measures, indicates, and records the moisture content of gases. Can be used for such control functions as proportioning, on-off switching, and alarm signaling of high or low dewpoint. Available with choice of standard electric or pneumatic control instruments, and with either round or strip chart recording. *Weighing & Controls, Inc.*

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General Purpose Valves

Forged steel general purpose gate, globe, and check valves have 150, 300, and 600 ASA flanges and face-to-face dimensions. Other features include hard faced seats and hardened wedges and discs; spiral wound body-bonnet gaskets; stainless steel gland studs and nuts, and interchangeable parts. Available in ½ to 2-in. sizes. *Henry Vogt Machine Co.*

Circle number (56) on reply card.

Butyl Chopper

A large "wood hog" shredding machine designed for the pulpwood industry chops 50-lb blocks of raw butyl into bits the size of rice grains. These fine pieces then can be dissolved quickly in a hydrocarbon solvent, speeding the production of butyl rubber. Process is being used at the Baton Rouge refinery of Esso Standard, Division of Humble Oil and Refining Co. *Esso Research Laboratories.*

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reminder:

see

SOLVAY

for

ALUMINUM CHLORIDE!

98% pure or better. Meets rigid chemical specifications. Available coarse screened, medium screened, fine screened, extra fine grind.

Used for producing detergent intermediates and other alkylates . . . isomerization . . . polymerization . . . varied Friedel-Crafts syntheses.

Write for literature and prices.

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HALF a MAN

is not enough!

human interests must balance technical efficiency

Consistent improvement has been made over the years in the quality and service of Western Heat Exchangers, as well as in providing more effective solutions to the heat transfer problems of our customers by recognizing the need for keener insight into the personalities and problems of the **people** with whom we deal — our suppliers, customers, employees and associates.

Every advance we have made in design, mechanics, metallurgy and fabrication is the product of **engineers** — not engineering — **creative individuals** whose technical proficiency is balanced by their understanding of the individual problems of the people we serve and with whom we work.

Increased efficiency, longer life, less maintenance, lower costs — these are the benefits that accrue to Western customers as a result of this philosophy of business. **We could do no less for you, given the opportunity.**

WESTERN'S STAKE IN YOUR FUTURE

. . . is in the hands of men — *whole* men — whose professional acumen is matched by an insight to the human relationships in engineering. This vital need is more completely exposed in the latest of Western's "engineer-advancement" messages, the first few lines of which are shown at right. A complete pamphlet on the subject is available to you, singly or in quantity, upon request.

One of a series appearing in OIL & GAS JOURNAL, CHEMICAL ENGINEERING, PETROLEUM REFINER, REFINING ENGINEER, CHEMICAL ENGINEERING PROGRESS.

Facts-of-Life for successful engineers must include attitude, self-appraisal, vision, understanding, respect, relaxation and "happiness"

Achieving "success" and/or "happiness" in your professional and personal future won't just "happen," regardless of how diligently you apply yourself to your daily tasks, unless your efforts are coordinated along specific paths of endeavor. Your life as an engineer must be counterbalanced by your life as an individual — because "engineers ARE human," despite comment to the contrary.

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"They engineered this oil line to a cat's whisker"—then wrapped it with Polyken tape

One of the world's largest pipeline operators chooses the world's toughest tape coating for new Patagonian oil line

A leading international pipeline company recently wrapped over 100 miles of crude oil gathering and transmission line with Polyken No. 960 Extra-Strength Pipeline Roll.

The new line, which crosses part of the Patagonian plateau of southern Argentina, is an example of perfection in pipeline design. "They engineered it to a cat's whisker," is the way a seasoned pipeliner put it.

In their construction plans, the engineers specifically called for Polyken No. 960 Tape. Seven years of testing and study had convinced these people that Polyken delivers the durable, practical protection that a precision-built line needs.

There's a lot more to be said for Polyken tape. See your Polyken representative, or call the Polyken tape coating distributor nearest you. Or simply write Polyken, 309 West Jackson Blvd., Chicago 6, Ill.

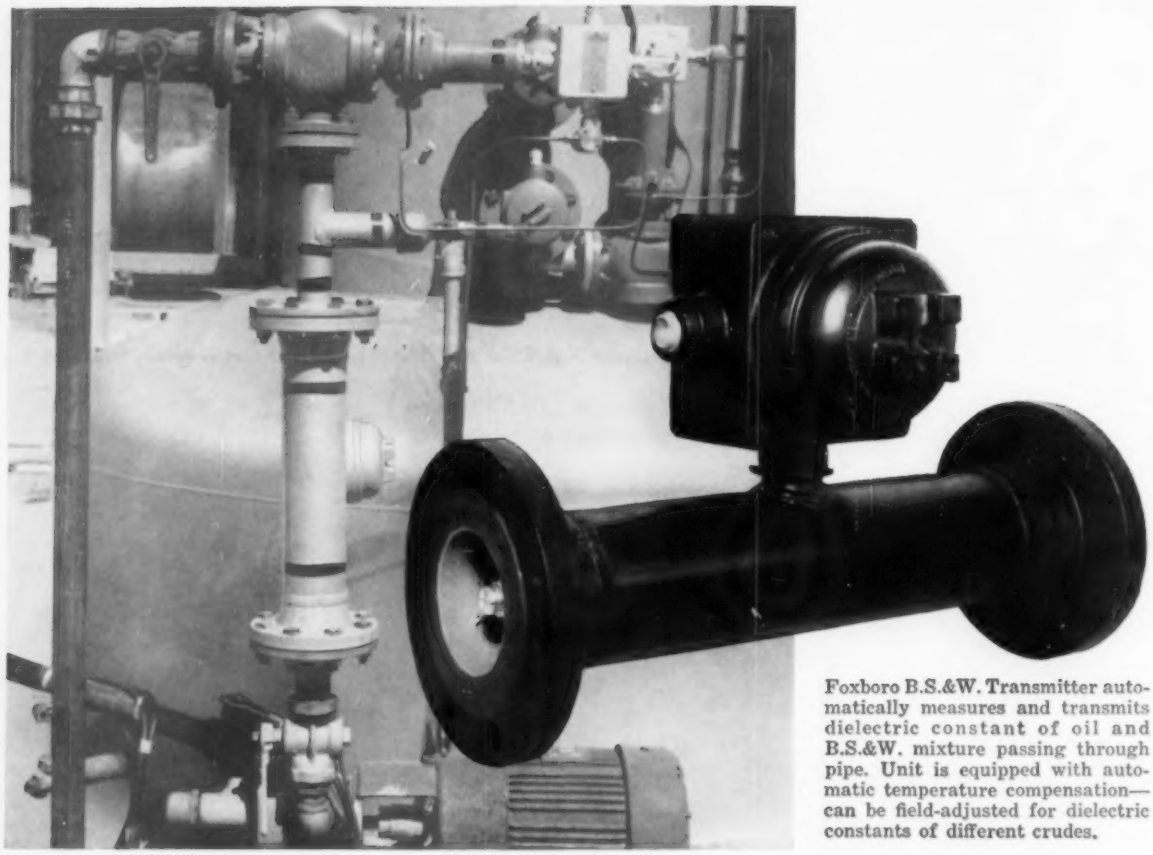
Using tensioned-spindle equipment, pipe is cleaned and wrapped in one factory-smooth operation. Polyken tape is ready. No primer, no drying or cooling. No fumes or fire hazard.

THE MODERN WAY

Polyken®

EXPERIENCED IN PROTECTIVE COATINGS

THE KENDALL COMPANY
Polyken Sales Division



Foxboro B.S.&W. Transmitter automatically measures and transmits dielectric constant of oil and B.S.&W. mixture passing through pipe. Unit is equipped with automatic temperature compensation—can be field-adjusted for dielectric constants of different crudes.

unique Foxboro system gives continuous, unattended measurement of B. S. & W.

— *plus records to prove it.*

The instant the B.S.&W. content of crude oil exceeds preset percentage you know it, with this unique Foxboro monitoring system.

Here's how. A Foxboro measuring element, installed in the pipeline, continuously measures B.S.&W. content of the crude, in terms of dielectric constant. Changes in dielectric are then transmitted electrically to a Foxboro capacity Dynalog* Recorder.

And that's it. Remedial action can be incorporated by having the Dynalog Recorder equipped with an electric contact for sounding an alarm or operating diversion valves to re-route off-spec oil.

Not only does the Foxboro B.S.&W. System fully meet the specifications of A.P.I. Bulletin 2509A, but also it is the most accurate, automatic, and trouble-free method of policing B.S.&W. available. Ask your nearby Foxboro sales engineer for details. He can tell you about dozens of these systems now at work throughout the world. **The Foxboro Company, 388 Norfolk Street, Foxboro, Mass.**

*Reg. U. S. Pat. Off.

Capacity Dynalog Recorder (lower instrument) receives measurement from B.S.&W. Transmitter, records it, and initiates alarms or re-routing of oil flow.

FOXBORO instrumentation

REG. U.S. PAT. OFF.

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SHAPING THE FUTURE

. . . in Pipelining

WHETHER GAS STORED UNDERGROUND IS SUBJECT TO THE LAW OF CAPTURE, is an important legal point Lone Star Gas Company is attempting to establish by court action. Into a depleted lime reservoir in the Tri-Cities field, East Texas, the company injected some 21 billion cu ft of gas after the Texas Railroad Commission had classified it as a gas storage zone and it had been unitized for this purpose. One of the lease owners on the 2400-acre tract involved, Sanders & Murchison, did not sign the unit agreement, however, and last year completed a producing gas well having a potential of about 900,000 cu ft a day. Lone Star says the well is producing from the storage area, and seeks damages, as well as a precedent ruling, which will have a widespread effect on gas-storage operations in Texas and possibly elsewhere.

A NEW CONCEPT IN UNDERWATER STORAGE has been installed off St. Petersburg Beach, Florida, for liquids, solids, and gases. Collapsible tanks made of special rubber-impregnated fabrics, which are impervious to the elements and can withstand high hydrostatic pressures, have been anchored in 40 ft of water. Among the uses visualized are storage of petroleum products and natural gas at certain effective locations.

HIGH-STRENGTH 42-IN. DIAMETER PIPE is now a reality. The pipe is being produced by Bethlehem Steel Corporation in accordance with American Petroleum Institute 5LX52 specifications. Previously, the largest size meeting these specifications was 36-in. OD. According to reports, at least two gas pipeline companies are considering installing the 42-in. pipe.

A JOINT TARIFF HAS BEEN ISSUED by Minnesota Pipe Line Company and the Soo Line Railroad on crude oil transported from North Dakota and Montana to refineries in the Minneapolis-St. Paul area, the first rate of this kind ever filed with the Interstate Commerce Commission. Soo will move the crude to Clearbrook, Minnesota, where it will enter the pipeline. The joint rate is 70 cents a bbl compared to 84 cents previously charged by Soo to take it all the way. Great Northern Railway has countered with a rate of 69.7 cents a bbl from the same producing areas to Minneapolis-St. Paul.

AUTOMATIC WELDING OF PIPE IN A FIXED POSITION (without rotation) and without back-up rings, is claimed by the Russians. A twin-arc unit for carbon-dioxide shielded-arc welding of pipe joints was tested in constructing the Shebelinka-Belgorod gas pipeline, it is asserted. Pipe diameter was 28 in. and wall thickness 0.312-0.390 in.

SUPER-INCH MONEY-MAKER

Allis-Chalmers 225-hp HD-21 has the power, side boom capacity and over-all strength to make money for you on the biggest pipe—and the over-all design superiority to do it in any kind of terrain.

Pipeliners are using Allis-Chalmers HD-21 side boom crawlers to handle the biggest pipe loads; 34-in., 36-in., 42-in.—and heaviest of all—the concrete-coated pipe. And these big-capacity machines not only move right along with the super-inch stuff, but they also work profitably on medium-inch lines.

When you consider your next pipeline tractor spread, look at every factor—original cost, fuel consumption, ease of maintenance, life of components, over-all performance, nationwide dealer service—and you can look to Allis-Chalmers for your best tractor buy.

Note the rocky, abrasive ground in this picture. There's just one track that's made-to-order for this rough stuff—that's Allis-Chalmers. Special steels that are specially heat-treated make these track shoes, side bars, track pins and bushings the industry's toughest.

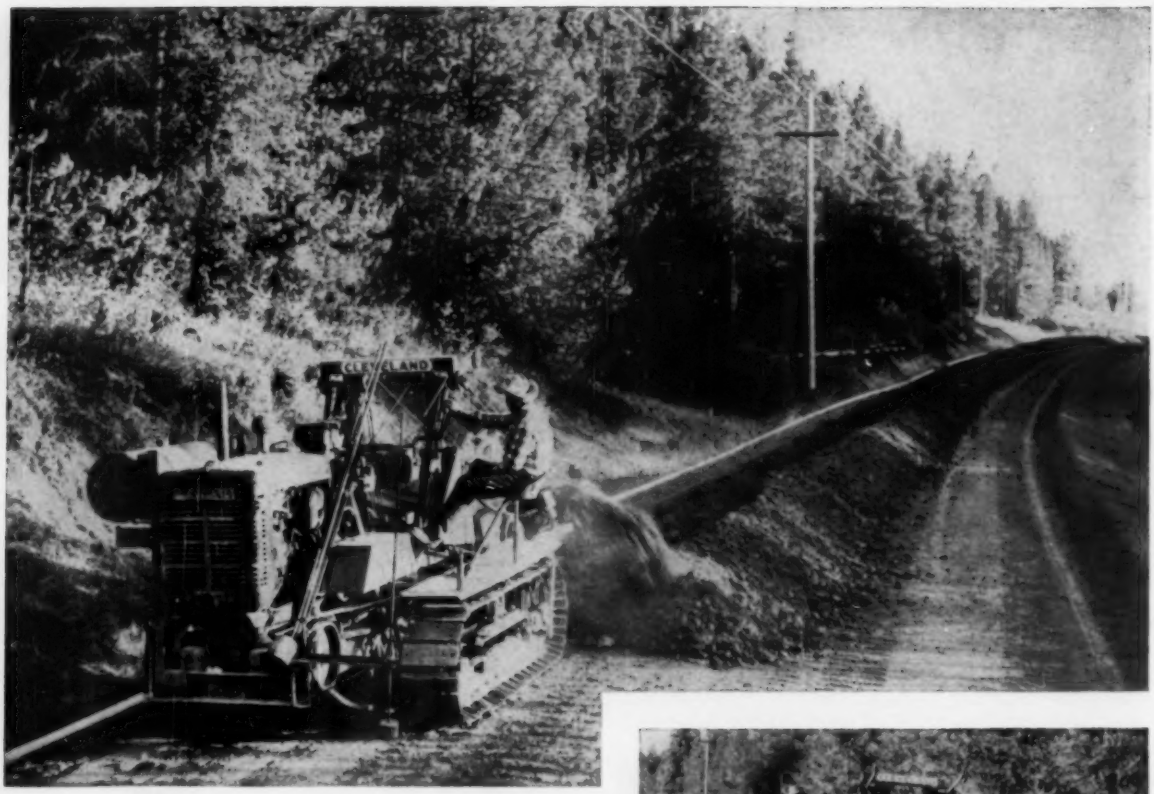
One last point. Pipeliners say nothing matches an Allis-Chalmers side boom tractor for flotation and maneuverability in muddy, swampy going. A tractor that's dependable in mud is good anywhere. Your Allis-Chalmers construction machinery dealer is eager to prove it with a demonstration. He is also in a position to give you the best possible terms. Allis-Chalmers, Construction Machinery Division, Milwaukee 1, Wisconsin.

HD-21
Crawler Tractor

- *225 net engine hp*
- *Hydraulic torque converter drive*
- *Bare tractor weight: 46,200 lb (long track model)*
- *Weight with side boom: 79,050 lb*
- *Side boom lifting capacity: 127,000 lb at 4 ft*

move ahead with
ALLIS-CHALMERS
power for a growing world

VETERANS OF THREE YEARS OF TOUGH PIPELINING. These HD-21's are three years old and still going strong. Owner reports, "These tractors have been steady, dependable performers under tough operating conditions."



Cleveland 140 digs 38-mile Idaho gas extension

Massart Construction Company of Spokane, Wash. used a Cleveland 140 to dig a 38-mile gas line eastward from Moscow, Idaho to serve a new refractory at Boville, another brick plant at Deary and smaller users along the line. The Cleveland dug the line 40 inches deep for 4 and 6-inch pipe at a rate of better than 2 miles per day.

Typical of the entire Cleveland Trencher line, the 140 provides over 30 non-slipping digging wheel speed-and-power combinations—a choice that gives maximum trench production in all soils and terrains with greatest economy for every type and size of digging within its range.

For gas distribution and service lines, for gathering and transmission lines... for pipelines of every kind... for water and sewer lines... for drainage and irrigation systems... for every trenching requirement... for dependability, speed and economy... nothing digs trench like a Cleveland.

Check with your distributor now—get the complete story on Clevelands

Good Everywhere

The CLEVELAND TRENCHER Co.

20100 St. Clair Avenue • Cleveland 17, Ohio

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These experienced buyers of 2-way radio specify Motorola more often than all others combined...

• FIRE

• TAXI

• MANUFACTURING

• PUBLIC UTILITY

• CONSTRUCTION

• RAILROAD

• POLICE

• TRUCKING

Here's why your business can profit from the experiences of these long-time users.

1. *MOTOROLA has the most reliable equipment for long-run economy.* Records of experienced buyers *prove* Motorola 2-way radio works better, longer—therefore, it costs less.

2. *MOTOROLA engineers the radio system for your specific job.* Motorola sells exclusively through factory-employed 2-way radio sales engineers. You can always look directly to Motorola to completely satisfy your 2-way radio requirements.

3. *MOTOROLA equipment matches the job.* Motorola has the world's most extensive line—thousands of installations. There is a model to exactly meet *your* system needs.

4. *MOTOROLA provides nearby, expert service.* Motorola—through its nearby Service Center—will provide regular, programmed maintenance and assume full and undivided responsibility for the continuing peak operation of your system.

. . . Four excellent reasons why you should ask Motorola to plan *your* 2-way radio system.

Motorola . . . the communications specialist to industry for nearly three decades

MOTOROLA 2-WAY RADIO

Motorola Communications & Electronics, Inc., 4501 Augusta Blvd., Chicago 51, Ill.

A Subsidiary of Motorola Inc. SPaulding 2-6500

CAMPO DURAN PIPELINE GETS 40,000 DEPENDABLE HORSEPOWER

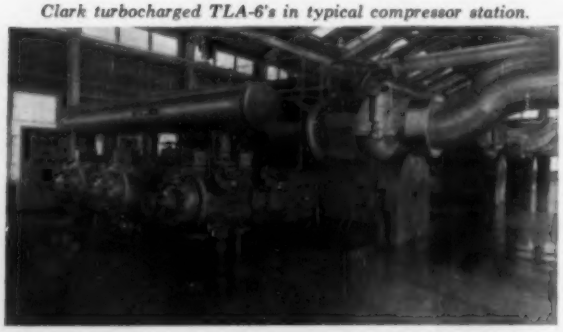
Twenty CLARK Turbocharged TLA-6 Compressors selected by Argentina's YPF

On the newly completed 22" and 24" Campo Duran gas pipeline in Argentina, there will always be extra compressor power on hand to meet emergencies. Each of the twenty 2,000 bhp Clark turbocharged TLA-6's has ample power reserve to handle temporary overloads with ease.

In specifying Clark TLA-6 gas-engine-driven compressors, YPF engineers gave full consideration to proved dependability, economy of operation, and the fact that the new Clark cylinder and valve design increases compressor efficiency by 15%. In fact, the recently introduced Clark low ratio compressor cylinder and matching nylon poppet valve assure unequalled loading flexibility plus optimum compression efficiency at ratios of 1.2 or less.

There are seven models of Clark TLA and TRA compressors available in the 1100-3400 bhp range, whether manufactured under license in Europe or in the Clark home plant in the U.S.A. All units and components are identical and completely interchangeable. For complete data, consult your nearest Clark office.

Clark turbocharged TLA-6's in typical compressor station.



CLARK BROS. CO., Olean, New York

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DRESSER INDUSTRIES INC.
OIL • GAS • CHEMICAL
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CLARK BROS. CO., OVERSEAS OPERATIONS DIVISION
122 East 42nd Street, New York 17, N. Y.

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Mr. Wayne Albertson, left, Engineering Inspector, and Leo Crowder, Koppers serviceman, inspect the pipeline coatings.

"It pays to have a Koppers serviceman on these really big pipeline jobs"

That's how Wayne Albertson, Engineering Inspector for Black & Veatch, Consulting Engineers of Kansas City, evaluated Leo Crowder's work as a Koppers serviceman on St. Paul's new gigantic pipeline project. This 90" steel waterline will carry 90 million gpd of fresh water four and one-half miles from Lake Vadnais to St. Paul's filtration plant.

Mr. Albertson stressed the importance of having a coating specialist present on the job. He said, "A pipeline is only as good as the protective coating job; and the best assurance of top-rate coating protection is to have a specialist on hand who has worked with these problems before. He can often quickly solve pipeline coating problems that might consume days of our time."

Each of the mammoth pipe sections welded together on this installation was shop coated with Bitumastic® 70-B AWWA Primer and Enamel, and wrapped by Bethlehem Steel Company before shipment to St. Paul. Following the welding operation, the pipe joints were given another heavy coating of Bitumastic 70-B AWWA Enamel and glass and felt wraps to give the joints permanent protection against corrosion.

A Koppers serviceman can show you how to get long-range corrosion protection with Bitumastic protective coatings. For more information on the complete Koppers coating line, mail the coupon or write: Koppers Company, Inc., Tar Products Division, Pittsburgh 19, Pa. District Offices: Boston, Chicago, Los Angeles, Pittsburgh, New York, Woodward, Ala., and Houston, Texas (Mavor-Kelly Co.). In Canada: Koppers Products, Ltd., Toronto, Ontario.

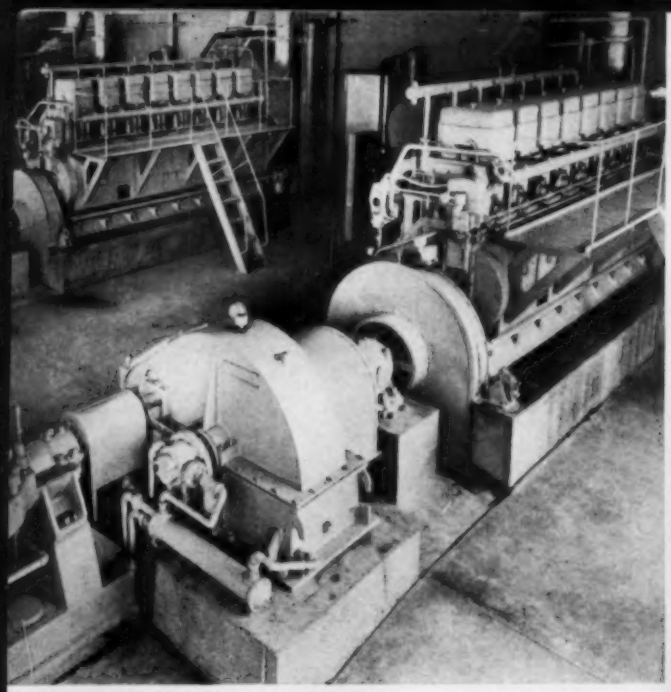
KOPPERS

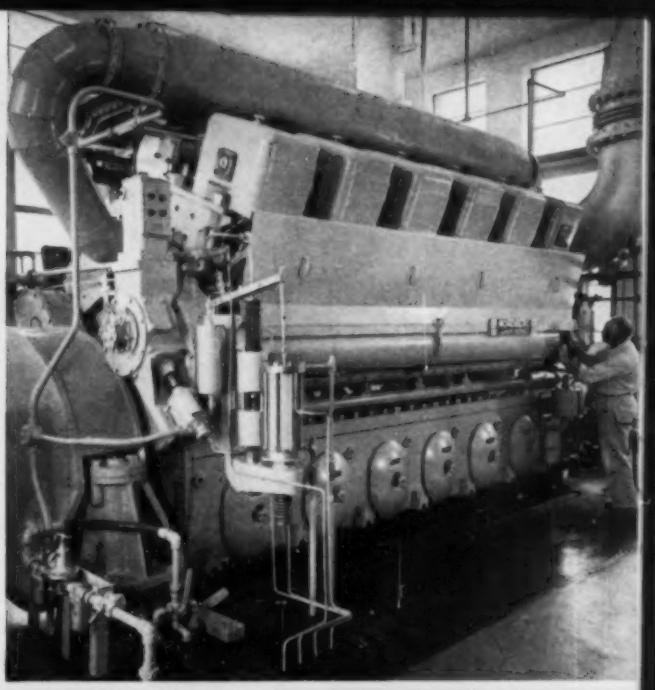
KOPPERS
BITUMASTIC
COATINGS AND ENAMELS
another fine product of COAL TAR

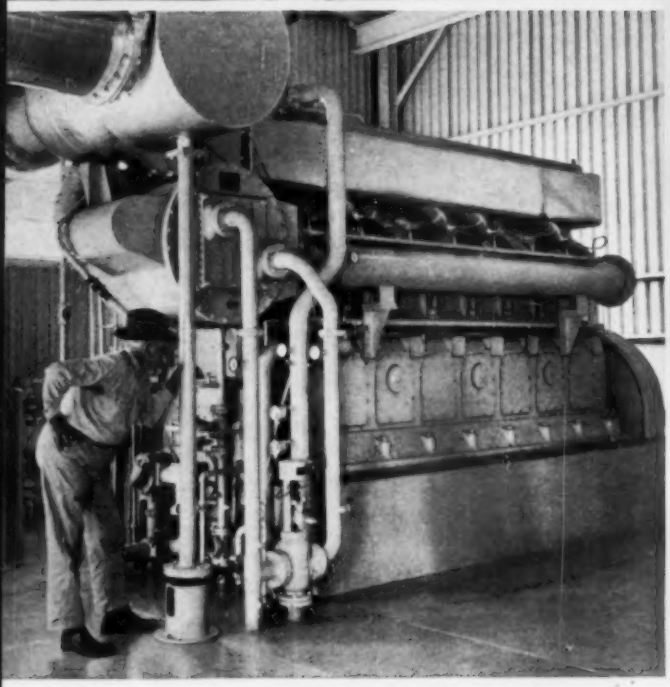
GEM

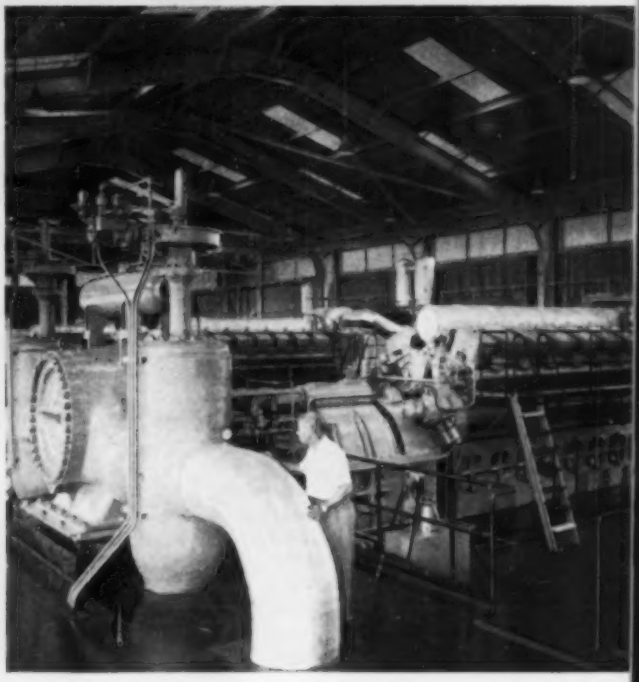
Koppers Company, Inc., Tar Products Division
Dept. 105-H, Pittsburgh 19, Pa.
Gentlemen:
I would like a copy of your booklet on pipeline coatings, "How Long Should A Pipeline Last?"

Name_____ Title_____
Firm_____
Address_____
City_____ Zone____ State_____









Pipe line engines by Nordberg

Nordberg engines are a sound investment in long term pipe line power. Consult Nordberg on your crude, products or gas pipe line programs.

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O-260

NORDBERG MANUFACTURING COMPANY

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NEW ORLEANS • NEW YORK • ST. LOUIS • SAN FRANCISCO • TAMPA
WASHINGTON • TORONTO • VANCOUVER • JOHANNESBURG • LONDON • MEXICO, D. F.

"... Let's play it safe–let's order GS 434 for the entire line.."

The cost of pipe coatings is a minute fraction of the total cost of a pipeline. And dollar savings between the most expensive and inexpensive is an even more minute fraction of total cost. It's obvious that the critical consideration in the selection of a pipe coating is not cost . . *but degree of protection afforded.*

It's particularly significant that of all materials and products, GS 474 Primer and GS 434 Enamel were used —*exclusively* — on the YPF Argentine job.

Why were GS products chosen? Because they provide a greater degree of protection against a wider range of deteriorative forces than any other pipe coating. It's that simple.

If there are some facts you would like to know about asphalt pipe enamels, write Lloyd Bramble or Cecil Redding —or, better still, call them at CApitol 4-2507, Houston, collect.

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Superior quality 12¾" O.D. J&L Electricweld line pipe was used for 17 miles of this Northern Oklahoma Gas Company line from Cherokee to Ponca City. The line will serve the towns of Ponca City, Perry and Newkirk, Oklahoma, and area industries. J&L line pipe is available in sizes from 6⅝" to 12¾".

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Contractor for coating and wrapping:
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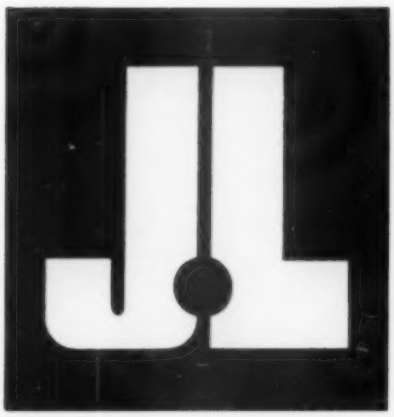
Pipe laying operations with this J&L Electricweld line pipe are fast and efficient. Weldability is excellent. Pipe is 29.28 pounds per foot, .219" wall, X-46 grade.



Reliable field performance is assured because every length of J&L pipe undergoes a specified hydrostatic pressure test which proves its dependability under sustained and surge pressures.

This ultrasonic tester provides immediate pictures of weld soundness in all J&L Electricweld line pipe. It is one of the most advanced control devices in pipe-making.

Quality control at J&L pays off on a job at Cherokee

Every length of J&L line pipe passes over 50 quality tests before it enters the field

Total quality control of J&L Electricweld line pipe is maintained through more than 50 control measures and tests on every length of pipe.

Crush tests assure weld strength and steel quality. A modern ultrasonic device probes soundness of the weld. All joint ends are magnafluxed to assure freedom from flaws. Every length is full-pressure tested under specified A.P.I. or A.S.T.M. hydrostatic test requirements, both in time and degree of pressure. These are a few of the stringent controls that assure complete dependability of J&L Electricweld line pipe.

It pays to specify plant-tested, field-proved J&L Electricweld pipe for your transmission, distribution or gathering lines. Write for J&L's new bulletin.

Jones & Laughlin Steel Corporation

PITTSBURGH, PENNSYLVANIA

ARGENTINE PROJECT

. . *unique pipeline construction*

IN A SENSE the Campo Duran Project of Argentina's Yacimientos Petroliferos Fiscales (YPF) might be termed a "do-it-yourself" project, applied in this instance to a group of engineering and construction organizations rather than to an individual.

Installation of 2000 miles of gas and products pipelines, dual field gathering system with low temperature separation units, a gasoline plant for processing seven products, four compressor stations, eight pump stations, terminal and delivery facilities, power generation, and a microwave communications system involved far more than just the construction of these facilities.

Faced with a financing program that involved currencies and credits of eight countries, arrangements first had to be made for the manufacture of equipment in many parts of the world. As most of it was manufactured in these countries for the first time, designs were based on American licenses and/or

Map—Gas and products pipelines both originate in Campo Duran area. Gas system terminates at Buenos Aires, products line at YPF's San Lorenzo refinery.

know-how, with technical assistance provided by the overall engineering and supervisory organization, International Pipeline Constructors, S.A. (IPCO).

The extent of the effort is indicated by the fact that a rolling mill had to be established in Argentina for fabrication of pipe for the products system using plate imported from Japan; a mill was enlarged in Italy to make 24-in. pipe for the gas line; a plant was set up in Argentina for production of asphalt coating; and another for casting concrete weights for use in swamps and rivers.

On the construction job, because of the right-of-way's isolation, entire mobile cities were provided for workmen, completely equipped with water, electricity, and sanitary facilities. Air strips were bulldozed out of the rough terrain for light and medium aircraft, used to transport personnel, equipment, and foodstuff.

A fabrication shop conveniently located, where valve assemblies, vessels, piping, etc., could be fabricated instead of in the field and thus take advantage of better equipment, aided greatly in the success of the overall operation. This plant also served as a supply depot.

Pipe and other equipment shipped from around the world required the services of a major shipping fleet . . . some 400 vessel loads were included in this operation for a period of 15 months. A lumber plant in Argentina was leased to make the heavy wooden type cradles required on ship board for handling the pipe and provide dunnage for railway movement.

Shipments of gas line pipe alone totaled 200,000 metric tons, and 55,000 metric tons of pipe went into the products system.

Some 20,000 railroad carloads of material were moved within Argentina, and SARGO had a supplementary fleet of 275 Ford trucks of various types in action at all times, plus numerous leased domestic trucks.

On SARGO's payroll for a 15-month period during line construction were 2500 Nationals and 350 Americans, which does not include employees of Argentine sub-contractors.

These are some of the highlights that identify this Argentine undertaking as being without counterpart.

Constructors

The Campo Duran pipelines and associated facilities are being engineered and constructed for YPF by International Pipeline Constructors, S.A. (IPCO) who subcontracted various phases of the work to other companies due to the complexity of the operations and the urgent completion schedule. SARGO (S.A. Argentina Obras Oleoductos y Gasoductos) is handling all of the work in Argentina from construction offices in Buenos

Scene near Lumbreras . . . coating was applied to thickness of 3/32 in., reinforced with glass mat, and wrapped.

Firing line crew in vicinity of Lumbreras on south end of system.

Boring a road crossing near Tucuman.

Aires. Fish International Corporation, Panama, is performing all engineering for the project and is responsible for supervision of construction. Fish staffed the SARGO organization with the necessary construction and supervisory personnel. These experienced pipeliners and engineers had previously worked with Fish on the Transcontinental Gas and Pacific Northwest pipelines in the United States.

IPCO subcontracted purchasing functions to NORICAN and NORICANSA for procurement and shipment of all materials and equipment outside of Argentina. SARGO purchased materials in Argentina wherever quality standards could be met and delivery assured. This local purchasing program prompted many Argentine manufacturers and suppliers to expand their facilities and install new equipment. Technical assistance was furnished to many industries, which will now be able to provide pipeline and oilfield equipment for future expansion.

Route of Pipeline Systems

The gas and products pipelines both originate in the Campo Duran field near the Argentina-Bolivia border and are fed by a gasoline extraction and dehydration plant, the only instance of a pipeline network of such magnitude being served by a single installation.

The gas transmission line consists of 1100 miles of 22 and 24-in. pipe, terminating at Buenos Aires, the products line of 900 miles of 12-in. pipe, ending at YPF's refinery at San Lorenzo. Previously, 330 miles of this line had been constructed from Campo Duran as far as Tucuman. The two lines parallel each other as far as Canada de Gomez, where the products system takes off northeastward to San Lorenzo and the gas line continues southeastward to Buenos Aires.

Although limited quantities of gas and stabilized distillate have been transported through the lines since March, the two systems were not entirely completed until the early part of July. The gasoline plant is scheduled for completion in the fall.

The project will cost in excess of $200,000,000, but the Argentine government feels this is a reasonable price to pay for more than doubling the country's available gas supply and adding 57,000 bbl per day of petroleum to Argentina's goal of self-sufficiency in oil. As side benefits, the pipe mill provided for this project, the coating manufacturing plant, and other facilities become permanent installations to further benefit the country's economy.

Construction Methods

Terrain. The right-of-way is through widely varying terrain. Campo Duran is in semi-tropical hill country. Southward is heavy timber, actually a thicket in many places, and rocky foothills. Emerging from this area, the line crosses great salt flats in the Province of Salta, known as Salinas Grandes, about 40 miles across. The hardness of this formation necessitated major blasting and also presents a corrosion problem. In Central Argentina sugar cane, wheat and grain crops are grown. The areas growing sugar cane were wet and swampy due to irrigation and the pipe had to be weighted with concrete clamps. On the southern end of the system for several hundred miles are the famous Argentina grasslands.

Actually, terrain presented no unusual problem, as all these types are to be found in the U. S. and are familiar to construction crews. The isolation of the right-of-way, however, was a major factor because transportation of equipment and food and providing proper housing was a difficult matter. Communications were difficult to main-

Tricky Rio Las Piedras was tamed by straightening the channel and cutting down banks to give a gentle slope to the pipe . . . 100,000 yards of gravel was moved.

Four trenching machines of this type opened 1100 miles of ditch for the gas line without overhaul.

tain all along the pipeline with all message traffic on a 2-way temporary radio hookup.

The deep water port of Rosario was chosen as the supply point. Situated on Rio Parana, Rosario is one of Argentina's main ports. It is also a railroad center, making it naturally suited to receiving equipment from various parts of the world, and shipping it to the right-of-way. Facilities were provided at Rosario for storing equipment until needed, or until railroad cars became available for shipment. From Rosario north to Tucuman, the railroad is standard gage. At that point equipment had to be transferred to a narrow gage road to continue north to railhead, from where it was taken to jobsite on lowboys. Basically, the pipeline follows the railroad right-of-way, although at some points they were 15 miles apart.

Before utilizing the railroad system SARGO calculated the ratings of many bridges to determine the weights they would withstand. Side and overhead clearance had to be modified in several instances. As supplementary equipment, four flat cars had to be specially made for transporting some of the large vessels. These were built at the nationally owned Belgrano Railroad Shop. Other railway rolling stock had to be reinforced to carry the unusual tonnage.

Fabrication shop. A major factor in the construction work was the fabrication shop established at Rosario. Workwise this was the project's heart. A tremendously large warehouse stored thousands of items of equipment and parts . . . spare parts inventory alone totaled millions of dollars. In the shop many prefabrication jobs could be done better than in the field because of more efficient equipment than could be made available on the line and at station sites. Block valve assemblies were fabricated here as were most of the inlet and exhaust headers. Complicated pipe bends for compressor stations, vessels, crossing markers, and many other items were made at the shop. An important factor was in having the proper prestressing and X-ray equipment to assure products that would meet specifications before they were sent to the field.

Some major truck repairs were made here, although, of course, most repairs had to be made on the line either at campsite or from portable shops.

Complete plants were built for generating and bottling acetylene and oxygen, used principally for cutting. The acetylene plant doubled the supply of that product in Argentina and the oxygen plant was the largest in the country.

Coming from great distances, many pipe ends had been damaged in transportation and had to be cut and rebeveled. This was done at Rosario before shipping to the field.

Automatic welding equipment was provided for making longitudinal welds on suction and discharge bottles. The automatics were also used for welding large vessels received in sections due to weight and length limitations.

SARGO had its own welding school at this center to train welders for low pressure piping, and pipe rack work at compressor stations. These were national workmen who passed both the YPF and Fish Engineering tests before being sent out on the line.

A further important aspect of the Rosario center was the flexibility provided in handling materials. Equipment and materials were often off delivery schedule; and by holding stocks at a central point they could be dispatched to locations where the requirement was greatest.

River crossing. Nine major rivers were crossed but only two involved more than customary methods of con-

struction. Both the gas and products lines are carried on a 2100-ft highway bridge across Rio Bermejo on the northern part of the system.

Rio Bermejo is a treacherous stream, subject to flash floods and a tendency to funnel, greatly increasing velocity. Two highway bridges had gone out at this point and a new one was constructed at the same time as the pipelines were being laid. The lines were suspended on hangers on either side. Block valves were installed on both sides of the river and equipped with automatic line break operators. Should a rupture or break occur between the valves, they will automatically close.

The Rio Las Piedras, farther to the south but still on the northern section, had undercut the products line previously laid between Campo Duran and Tucuman. To tame this tricky river two things were done. The channel was straightened to lessen the erosion and cutting action. Each bank was cut down for a distance of 200 yards from river's edge, giving a gentle slope to the pipe on the approaches. To accomplish this, 100,000 yards of gravel was moved, and when the line was in place with concrete weights attached, the gravel was replaced. Minimum pipe cover for this river, whose channel was 300 yards across, is 15 ft minimum.

The other seven major rivers are primarily meandering streams, and the basic approach was to cut back a considerable distance from the banks and bury the pipe deep enough so that there would be no danger of the river exposing the line at some future time.

Pipe

Pipe installed in the main line of the gas transmission system was API 5LX, having a minimum yield strength of 52,000 psi. The line was telescoped, heavier wall pipe being used on the first section of the pipeline south of Campo Duran. These quantities were installed:

73.6 miles of 24-in. by 0.344-in. wall thickness.

236.1 miles of 24-in. by 0.312-in. wall thickness.

655.7 miles of 24-in. by 0.281-in. wall thickness.

133.6 miles of 22-in. by 0.250-in. wall thickness.

Minor quantities of greater wall thickness pipe were installed in par-

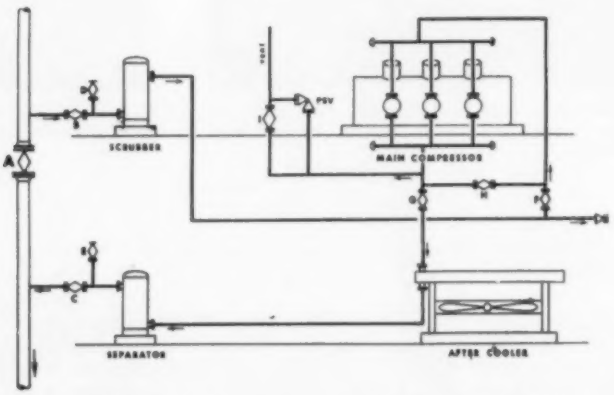
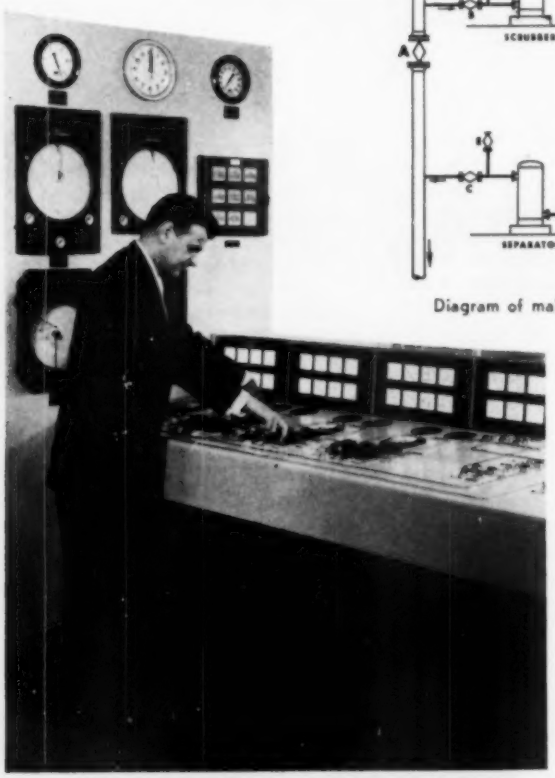


Diagram of main high-pressure gas piping at compressor stations.



Pump station operation on the products system is semi-automatic from a console in the central control room at each station. Shown is J. T. Cannan, general manager and chief engineer, Fish Engineering Corporation.

Preparing pipe ends by buffing for a tie-in at Sali Norte River crossing.

ticular locations where conditions dictated, such as river crossings, road crossings, and areas of dense population.

The 12-in. pipe in the Tucuman-San Lorenzo section of the products pipeline meets API 5LX specifications and has a minimum yield strength of 42,000 psi. Wall thickness is 0.281 in., except that heavier wall pipe was used in river crossings.

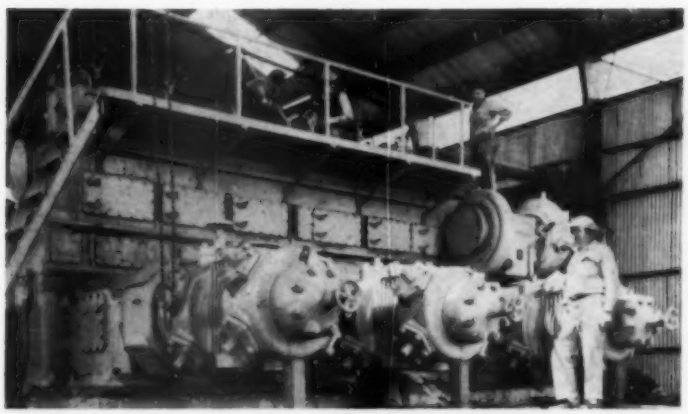
The pipe in the products system was hydrostatically tested to a maximum of 1400 psi, and in no case below 1200 psi. Pipe in the gas transmission system was hydrostatically tested at 1100 psi pressure.

As the facilities to roll pipe as large as 12 in. were extremely limited in Argentina, a privately owned plant near Buenos Aires was modernized for the purpose and technicians borrowed from Consolidated Western to supervise and inspect the product. Plate was imported from Japan and Austria. The mill will now become a permanent part of the country's industrial facilities, to provide for other liquid lines and gathering systems.

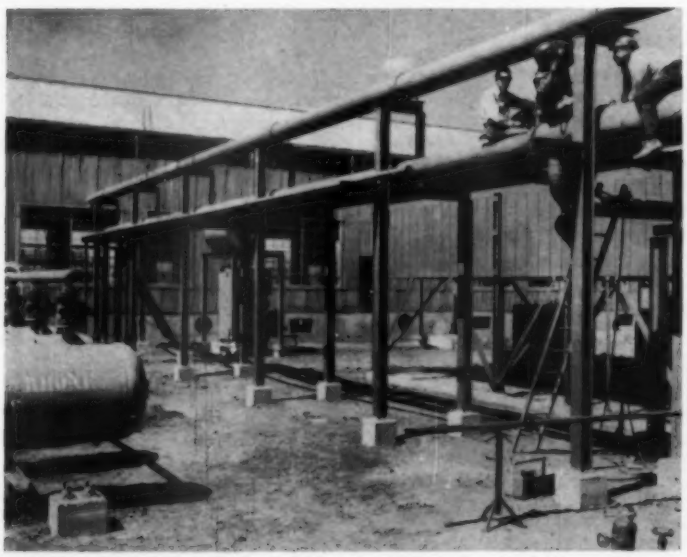
Pipe for the gas transmission system was made in Italy, France, Germany, England, and the U. S. In Italy, a pipe mill was modified and enlarged as there was no facility in that country for making pipe of the large diameters required. Technical assistance also was provided in each of the mills to check quality of the product.

Pipe that went into river crossings and swamps was made in the United States, as was the construction equipment . . . tractors, pipelayers, ditchers, bulldozers, coating and wrapping machines, backhoes, clamshells, cleaning and priming machines, trucks, welders, electrodes, etc. The limited number of dollars available in the financing program was used for this purpose.

Approximately 20 percent of the circumferential field welds were X-rayed, and at critical locations, such as river and highway crossings, bridge approaches, etc., were X-rayed 100 percent.



Compressor units consist of six vertical in-line power cylinders driving three horizontal double-acting compressor cylinders having a common shaft.



Installing overhead piping at Dean Funes compressor station. A YPF inspector, left, watches the work.

Main line block valves. Block valves on the main gas line are spaced at 15 to 20-mile intervals depending on geographic conditions. Operation is manual except those immediately upstream of pressure limiting stations 2, 3, and 4 on the northern end of the system. These valves are gas operated and are set to open and close at specified pressures. Side tap valves for the compressor stations are remotely operated from the control room of each station.

On the products pipeline system, block valves are placed at critical points. Each section of line between valves contains approximately 20,000 bbl of products, and should the necessity arise for draining a section, the pump station relief tank will be used for the purpose. The valves are through conduit type and are bevel gear operated manually. Side tap valves at storage station takeoffs are of the same type but motor operated remotely from the individual storage station.

Pressure limiting stations. Maximum allowable working pressure of the gas pipeline system varies throughout its length and to avoid exceeding these pressures pressure limiting stations have been provided. Stations 2, 3, and 4 are set to relieve slightly below maximum allowable working pressure of the pipe in the section immediately downstream. High pressure first causes the block valve to close and if pressure continues to increase, the relief valve opens venting gas to atmosphere.

Pressure relief valves on the products system are installed near each station, and in event of malfunctions liquid will be relieved to station tankage provided for this purpose.

Coating and wrapping pipe. Throughout most of their lengths, both the gas and products systems were given one coat of asphalt primer, one 3/32-in. minimum coat of asphalt enamel interwoven with glass fiber, and outerwrapped with kraft paper (in

Aircraft played an important role by transporting parts, personnel, and food to the spreads. Here, under an Acacia tree on the Dean Funes compressor station site a pilot checks over his machine.

some instances with asbestos felt). Exceptions to this protective program were river crossings, Salinas Grandes, and other areas where corrosion problems are more severe. In these cases, procedure was to apply one coat of asphalt primer, two 3/32-in. coats of asphalt enamel, two layers of glass fiber, and an outer wrap of kraft paper or asbestos felt.

Minor corrosion and pitting on the gas line pipe, caused by salt air in shipping, necessitated two passes of the cleaning machine before primer was applied.

During construction, the coating was inspected with holiday detectors for quality and satisfactory bond.

As a further means of protecting the pipe from corrosion, magnesium anodes were installed in the section crossing the Salinas Grandes, and that section insulated from the rest of the system by flanges. A resistivity survey will be made of the entire system at a later date after soil conditions have attained equilibrium. Recommendations will then be made for further corrosion control.

Compressor Stations

The gas transmission system has been designed to deliver 243,000,000 cu ft a day with four compressor stations. The stations are at Lumbreras, Lavalle, Dean Funes, and Monte Lena. Two of the stations have five 2000-hp compressor units and two, four 2000-hp units. Horsepower rating is at 300 rpm. The units consist of six vertical in-line power cylinders driving three horizontal double-acting compressor cylinders having a common crankshaft. The engines operate on the two-stroke cycle and burn natural gas fuel taken from the pipeline. Exhaust gas driven turbo-superchargers serve the dual functions of scavenging and supercharging.

Design maximum gas flow and corresponding inlet and discharge pressures at each station during first year of operation are as follows:

Station	Design flow, Mcf	Inlet pressure, psi	Discharge pressure, psi
Las Piedras (No. 1)	223,865	592	987
Lavalle (No. 2)	195,564	681	890
Dean Funes (No. 3)	190,674	649	890
Monte Lena (No. 4)	144,065	727	727

Electric power to drive engine auxiliaries that provide lighting is supplied by 3-cylinder, 4-stroke cycle, naturally aspirated, spark ignited, gas engines driving 152-kw, 750-rpm, 380-v, 3-phase, 50-cycle electric generators having direct connected exciters.

Each station has one spare compressor unit and one spare auxiliary unit.

Compressor and auxiliary engines are cooled by a common cooling water system, the water being pumped through engine jackets to finned tube air blown heat exchangers. Each station has its own water supply system for both the compressor station and employee housing.

Engine safety devices. Compressor units have been provided with safety devices to care for all eventualities. An engine overspeed shutdown switch is set to ground out the magneto and stop the engine when speed is from 340 to 350 rpm. An oil pressure shutdown switch grounds the magneto when pressure drops to 25-30 psi. The oil pressure shutdown device also can stop the engine by shutting off the engine fuel. When jacket water temperature becomes excessive, fuel supply is automatically shut off to stop the engine. High scavenging air pressure also will cause a shutdown by cutting off the fuel supply.

Three emergency shutdown stations are provided at each compressor station, making it possible for plant personnel to shut the station down completely in case of a line or connection break, fire, or explosion. When one of the emergency stations is manually energized, a quick-opening valve will bleed the pilot gas from the valve operators on the compressor station suction and discharge valves and blowdown valves. Bleeding the pilot gas from the operators actuates a controller, which vents the instrument air from the diaphragm of the fuel gas shutoff valve to the compressor, causing stoppage of the compressors. Generator engines are shutdown by means of a mercoid switch in the pilot gas line.

For ready access, the three emergency shutdown stations are located at the compressor building, office build-

ing, and shop and warehouse building.

The scrubber high level alarm and shutdown system functions in the same manner as the emergency system. On high liquid level in the gas scrubber, gas pressure is vented from the diaphragm of the engine fuel shutoff valve on all compressor engines only, stopping the fuel flow to these engines; generator engines cannot be shut down by the scrubber system.

Fuel gas system. Fuel gas for the plant and housing area, as well as power gas for valve operators, can be taken from the line at points upstream and downstream of the main line block valve, and after the scrubbers on the station suction line. Normally, the fuel gas take-off is downstream of the scrubbers.

Fuel gas is supplied at 550-psi line pressure and reduced in a reducing and metering station to 75 psi in two steps. The station also meters all fuel gas into the plant. For use as compressor fuel the gas is taken from the metering station and reduced from 75 to 30 psi by a pressure control valve. Generator engine fuel is reduced from 75 psi to 100 mm per water column. For the housing area, reduction is from 75 to 10 psi by a pressure regulator.

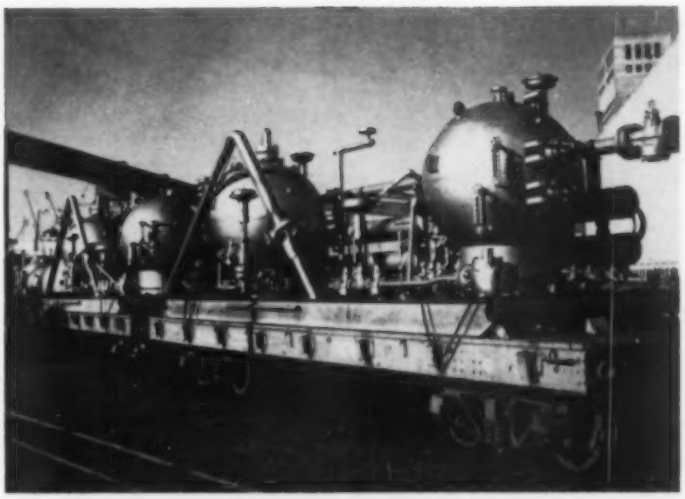
Gas coolers. Each station has a gas cooler on the discharge side to reduce the compressed gas to a temperature of approximately 125 F. Coolers have three coils and two fans, the latter driven by motors through gear reducers. Flexibility of operation can be accomplished by the number of fans used and/or by adjusting the pitch of the fan blades.

Jacket water pumps. Four motor-driven jacket water pumps are provided at each station, one serving as a spare. These centrifugal type pumps operate in parallel and are designed to develop a discharge pressure of 32 psi.

In addition to these pumps, an engine-driven pump is used for filling and flushing the system.

Air system. Sufficient capacity and storage facilities to provide air for starting gas compressor and generator engines, for operation of instruments and air tools, and for cleaning throughout the plant, have been installed. Included is one motor-driven compressor, one engine-driven compressor, and three 134.2 cu ft air receivers for storage. Also in the air system is a dryer for drying instrument air and filter regulators.

Gas scrubbers. Scrubbers installed on the suction line to the compressor



Skid-mounted low temperature extraction units separate gas, distillate, and water between producing wells and the Campo Duran gasoline plant. Units shown here are in railroad yards at Rosario ready for the journey north.

Vital to keeping the equipment running were the spare parts vans.

Trailer cities were established to house workmen in the field . . . these wheelless units were moved from one location to another on flat cars or lowboys.

"Heart" of the project was Rosario shop and warehouse where much of the fabrication was done and thousands of equipment items and parts assembled and stored.

stations are of the balanced flow, oil contact type, designed on the principle of entraining oil into the gas stream to wet and occlude the foreign particles. The amount of oil circulation for scrubbing action is controlled automatically. The scrubber is divided into four sections: (1) The gas-oil mixing section in the base for entraining oil into the gas stream at low gas throughput rates; (2) immediately above the mixing section is a disengaging space for lowering the mass velocity and releasing drops of oil from the gas stream; (3) a mist extractor element is located in the upper shell to remove liquid entrained in the gas stream, and (4) below the mist extractor is an oil reservoir for accumulating oil removed by the mist extractor.

Lube oil system. The lube oil system for supplying compressor and generator engines contains a pressure accumulator installed in the line from the lube oil pump to the dispensers in the compressor and auxiliary buildings. The accumulator supplies oil under pressure without the operation of the pump at all times. The system is pumped to a pressure of 40 psi, the pump then being shut off by a mercoid switch. When pressure declines, the lube oil pump is started automatically, repressuring the system.

The system for reclaiming crankcase oil from the compressor and generator engines is a continuous operation. As dirty oil from the units is purified in turn the cycle is repeated. The reclaimer also can be used for batch purification, but in the case of this transmission system is not.

Gas Sales Meter Stations

Twelve gas sales meter stations have been installed in the initial phase of the project, others to be added later as industrial expansion of the country progresses. The stations are at Vespucio, Tabacal, Ledesma, San Pedro, Cobos, Tucuman, Frias, Rosario, Villa Constitution, San Nicolas "A," San Nicolas "B," and Pacheco.

The stations are designed for two-stage pressure reduction with measurement being made at the intermediate 400-psi pressure level, except at Buenos Aires where the pressure is 300 psi.

Gas is scrubbed and entrained water extracted on the inlet side of each station. Measurement is by means of orifice meter tubes and recording flow meter.

Products Pump Stations

On the products pipeline system between Campo Duran and San Lorenzo there are nine pumping stations. The one at Campo Duran was constructed when the initial part of the system was built as far as Tucuman. The others are at Urundel, Lavayen, Los Piedras, Monteaguedo, Recreo, Quilino, Monte Cristo, and Montelena.

Stations are designed to pump seven products: Propane, butane, gasoline, motor fuel, crude distillate, kerosine, and gas oil/diesel.

Each station has four pumping units, one of which is used as a standby. Engines are connected to the centrifugal pumps through gear type speed increasers.

Station operation is semi-automatic from a console in the central control room, where the chief operator makes adjustments in accordance with desired discharge pressures as directed by the chief dispatching office in Buenos Aires.

Main pumping units. Engines are of the dual fuel type and will operate on diesel fuel or a mixture of 90 percent natural gas and 10 percent pilot fuel. The engines are 8-cylinder, 4-stroke, and at Los Piedros and Monteaguedo are supercharged because of the altitude, whereas the rest are naturally aspirated.

Engines are started on compressed air and are water cooled.

Automatic shutdown devices are incorporated for high jacket water temperature and low lubricating oil pressure. Should low fuel gas pressure occur, the engine will automatically change over to full diesel operation.

The lubricating oil system is self-contained, the oil circulating pump being operated off the engine.

Engines are provided with a hydraulic type governor capable of limiting instantaneous speed changes to 3 percent, with an instantaneous 25-percent load change. A pneumatic controller has been installed on the governor so that remote governor control may be effected later if desired.

Each engine cylinder is provided with pyrometers and associated thermocouples for analysis of exhaust gas.

Normally, these engines develop 500 bhp at 500 rpm, and are capable of 10 percent overload for one out of six hours operation. Continuous operation can be maintained between 300 and 500 rpm.

Pumps are heavy duty 2-stage centrifugals with cast bronze impellers statically and diametrically balanced. Rated capacity is 1680 gal per min at 1000-ft head, turning at 3600 rpm with 82-percent efficiency.

Speed increasers connecting engines and pumps are single train pressure lubricated herringbone type. The gear ratio is 1 to 7.2 with a maximum horsepower rating of 510 at 500 rpm.

Generators. Generators are 3-phase, synchronous, 10-pole that produce alternating current of 50 cps at 380 v for generating capacities of 125 kw

with a power factor of 0.8. They rotate at a speed of 600 rpm with a normal temperature rise of 158 F. The generators are driven by dual fuel engines that develop 230 hp at 600 rpm and are capable of a 10-percent overload. These engines are 6-cylinder, 4-stroke cycle. Each station has a standby generator unit.

Fuel system. Normally the dual fuel main line engines are operated on a mixture of 90 percent natural gas and 10 percent diesel fuel. Liquid fuel is extracted from the main line on the suction side of the station and stored in tanks having a total capacity of 21,000 gal. Injection into the fuel system is by head pressure.

Gas fuel is received from the gas pipeline, scrubbed, and warmed by jacket water in a heat exchanger prior to regulation. Metering and regulating equipment reduce the gas pressure from 1000 psi to 40 psi. For main engine pumping use an additional regulator is installed inside the pump station, and volume bottles equipped with relief valves provide a safe and smooth flow of gas to the engines.

Lubricating oil system. Main line engines have a self-contained lubricating system that includes filters, coolers, and storage. Pumps and gear speed increasers are lubricated by a self contained lube system. Temperature and pressure gages connected to panel mounted alarms are a safety check on overpressuring or excessive heating.

Cooling water system. The cooling water system is of the split flow type, one-half of the total circulating passing through the fan-type coolers and mixing with hot jacket water returning to the engines. Cooled jacket water passes through the engine jacket lube oil cooler, then is mixed with the hot jacket water before entering the engine. A temperature control valve, which receives its control power from a sensing element situated in the engine jacket water discharge, effects the proper mixture of hot and cooled jacket water. A bypass valve on the lube oil side controls the oil temperature, and no regulation of the amount of cooling water passing through the lube oil cooler is necessary. Additionally, a temperature recorder controller with sensing element is placed in the jacket water cooler outlet to control the variable pitch fan blades to further control cooling water temperature. Control of these fan blades in this manner compensates for normal or sudden ambient air changes.

Station central control system. Instrumentation is partly pneumatic and partly electric. Start-stop and alarm functions are electric whereas running controls are pneumatic. From a central console at each station all functions of normal operation can be carried out. Remote valve operation is accomplished through pushbuttons on the console. Station suction and discharge pressures are maintained and recorded, as well as gravity and suction temperature readings.

Continuous recording of the volume of liquid passing through the station is made on a flow recorder controller.

Recording gravitometers are used throughout the system to follow the movement of the different products.

An audio alarm system functions under the following conditions: Low station suction pressure, high station discharge pressure, low fuel gas pressure, low station air pressure, low instrument air pressure, low jacket water level, low fuel oil level, high bearing pump temperature, high gear oil temperature, high jacket water temperature, high engine lube oil temperature, high pump case temperature, and low engine lube oil filter discharge pressure.

Automatic shutdown of engines is caused by overspeed, low lube oil pressure, and low station suction pressure. An emergency also is provided that can be energized manually should need for complete station shutdown arise. This orderly electrical sequence is initiated at the console.

Incorporated into the station controls is a semi-automatic batching and scraper operation. Sending and receiving of batching pigs is automatically controlled through relays at the control console, requiring only manual insertion and extraction of pigs from the scraper barrels.

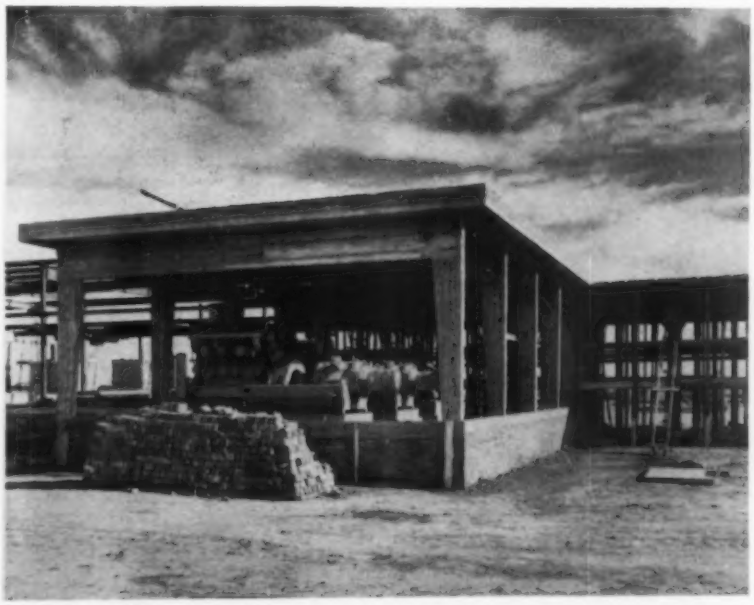
Storage stations. Storage stations at eight points provide sales outlets to various populated areas of northern Argentina. The storage stations are at Campo Duran, Vespucio, Salta, Tucuman, Recreo, Cordoba, Villa Maria, and San Lorenzo.

Both cone roof and floating roof tanks are utilized. Overpressure of the facility is prevented by regulators on the upstream side of the station set to close at a pressure exceeding 300 psi. Relief valves at strategic locations are set to relieve at 300 psi except in the case of the meter prover tank, which is 275 psi.

Strainers of the excelsior type remove dirt and water, and each station is provided with a spare so that the facility can be operable during changes of repacks.

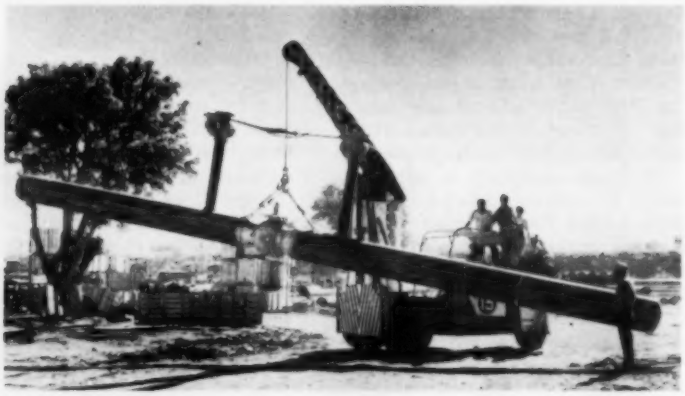
Meters give direct measurement of the quantities of each product delivered from the pipeline, and a meter prover tank is a part of the equipment. Here, again, spare meters are provided so that the stations are operable when a meter is being repaired.

The side tap valve for storage station



Supercharged 8-cylinder, 4-stroke, dual-fuel engines drive heavy duty centrifugal pumps on products system. Photo taken before completion shows design of station buildings.

Treacherous Rio Bermejo has torn out two highway bridges. Both pipelines are carried on this new one, built at the same time lines were being laid.



Fabrication of valve assemblies at Rosario shop helped speed construction in the field.

Cleaning machines had to make two passes over pipe to remove minor corrosion and pitting caused by salt air in shipping from Italy where it was manufactured.

connection to the main line can be remotely operated from the storage station. At Campo Duran and San Lorenzo there are remote reading gages so that each tank can be gaged from a central point. All other storage stations are equipped with automatic ground reading tank gages.

Switching manifolds are manually operated except at Campo Duran and San Lorenzo, which are remote control electric motor operated.

Communications

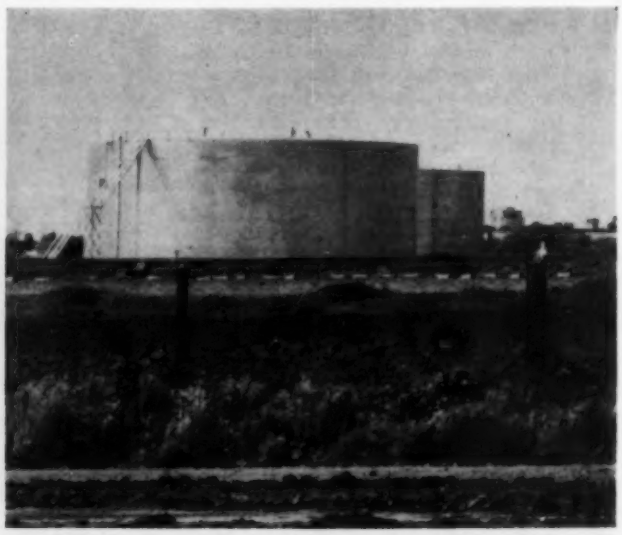
During construction two-way radio equipment was installed on a temporary basis so that SARGO's central office in Buenos Aires could talk with any station or spread camp. This is a single sideband VHF equipment. From stations and camps short range two-way radio makes it possible to communicate with trucks and other company cars in the field.

The radio equipment is being retained for operations until the microwave system, now being installed, is completed. This system provides for 36 channels, and there will be 41 tower locations and 60 generating units, some of the latter standbys.

Dispatching for both pipeline systems will be from Buenos Aires over the microwave facilities.

Gathering System

Wells in the Campo Duran and Madrejones fields produce natural gas accompanied by condensate and water. The gathering system is designed for



Refined products are taken from the pipeline at eight points along the

connection to 55 wells, 40 of which have been drilled at this time. Production from two to seven wells is gathered at one location for separation of distillate, gas, and water. Water is discharged and the distillate and gas transported to the gasoline plant through separate pipelines.

There are nine batteries of these skid-mounted low temperature separation units. The well stream enters the knockout vessel of the separation unit at a pressure of 3000 psi and temperature of approximately 113 F, and the liquid and gas separated. As the liquid still contains some dissolved gases and the gas is entrained with distillate and water, the dissolved gases are boiled off and the dew point of the gas reduced below normal pipeline transportation temperature. To remove the entrained condensate and water from the gas it is cooled by exchanging heat with the unit outgoing gas stream and its temperature further reduced by reducing the pressure from approximately 2800 psig to 1440 psig.

This second stage formation of liquid is separated from the gas and stabilized in the low temperature separator. Stabilization is effected by latent heat of stream provided through a steam coil in the bottom of the separator. Water is drawn off in the same vessel.

Dry gas is taken from the top of the separator, and, after exchanging heat with the incoming gas stream from the knockout drum, is fed to the gathering system trunk line.

Liquid from the knockout vessel, after reduction of its pressure to 1440 psig, is heated in a classifier to drive off dissolved gases and separate the water from the hydrocarbon phase. The gas stream from this classifier is combined with the gas stream from the low pressure separator. Water is discharged at this point to a drain system, and distillate is discharged to the liquid gathering trunk line.

The gas gathering trunk line, designed for an operating pressure of 1440 psi, consists of 12 and 16-in. pipe, having two intermediate block valves complete with blowdown facilities. Overpressure protection is by means of safety heads and pressure relief valves installed on the low temperature separators and classifiers at the batteries.

The liquid line consists of 4, 6, and 8-in. pipe, and also is operated at 1440 psi. Safety protection is the same as for the gas line. Two intermediate valves are installed on the line for segmenting purposes.

Both liquid and gas trunk lines are installed in the same right-of-way.

The gasoline plant will not be completed until sometime in the fall, and in the meantime liquid hydrocarbons are being pumped to San Lorenzo as stabilized distillate.

Air Fleet

Aircraft played an essential role in many phases of the project; in fact, without this mode of transportation the time schedule would have had to be extended immeasurably. Planes were used to deliver special parts, construction drawings, personal mail, food, and personnel.

Two courier planes, one on the north end of the system and one on the south, constantly shuttled back and forth. It took two days to complete a circuit, as they could fly only in the daytime. The maximum number of planes in service at one time was 12, ten Cessna 180s, a DC-3, and a de Havilland Dove.

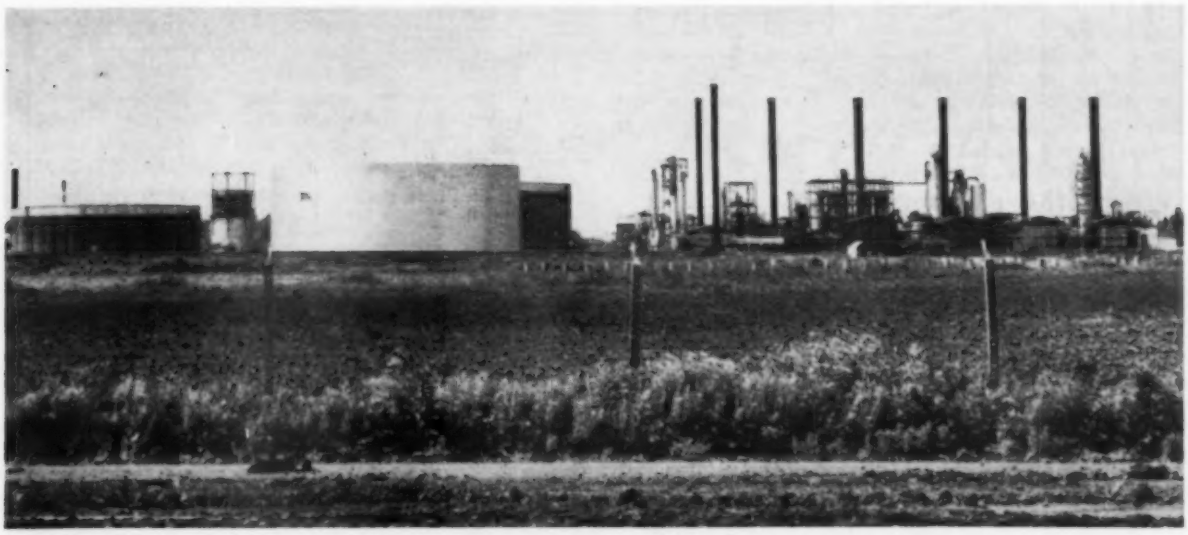
Camp Facilities

Towns were few and far between along the route of the pipeline, and providing living quarters and food were major matters. Trailer cities were set up and moved every 60 to 90 days as the work progressed. A water well was drilled, a water system laid out, power generating plant established, cesspool constructed, shower and toilet facilities installed, and a first aid station provided.

Workmen were housed in trailers without wheels, which were transported from one location to another on railroad flatcars or lowboys. Portable housing made of wood and canvas was also used. These units were in sections that could be bolted together to set up and knock down for transportation.

The kitchen trailers prepared meals in the camps and accommodated personnel traveling along the pipelines. Most foodstuff was purchased centrally and flown in.

Each spread had to be self-contained in other ways too. Remoteness made it necessary to have their own means of repairing vehicles and other equipment. Mobile spare parts trailers and mobile repair facilities, as well as a camp shop, served to keep equipment in top working condition. ★ ★ ★



route, but much of the load reaches this final destination . . . YPF's refinery and storage at San Lorenzo.

MARLAN G. JORDAN
Chief Engineer
Laurel Pipe Line Company

LAUREL'S CONCEPT OF CONTROL EQUIPMENT USE PROVES SOUND

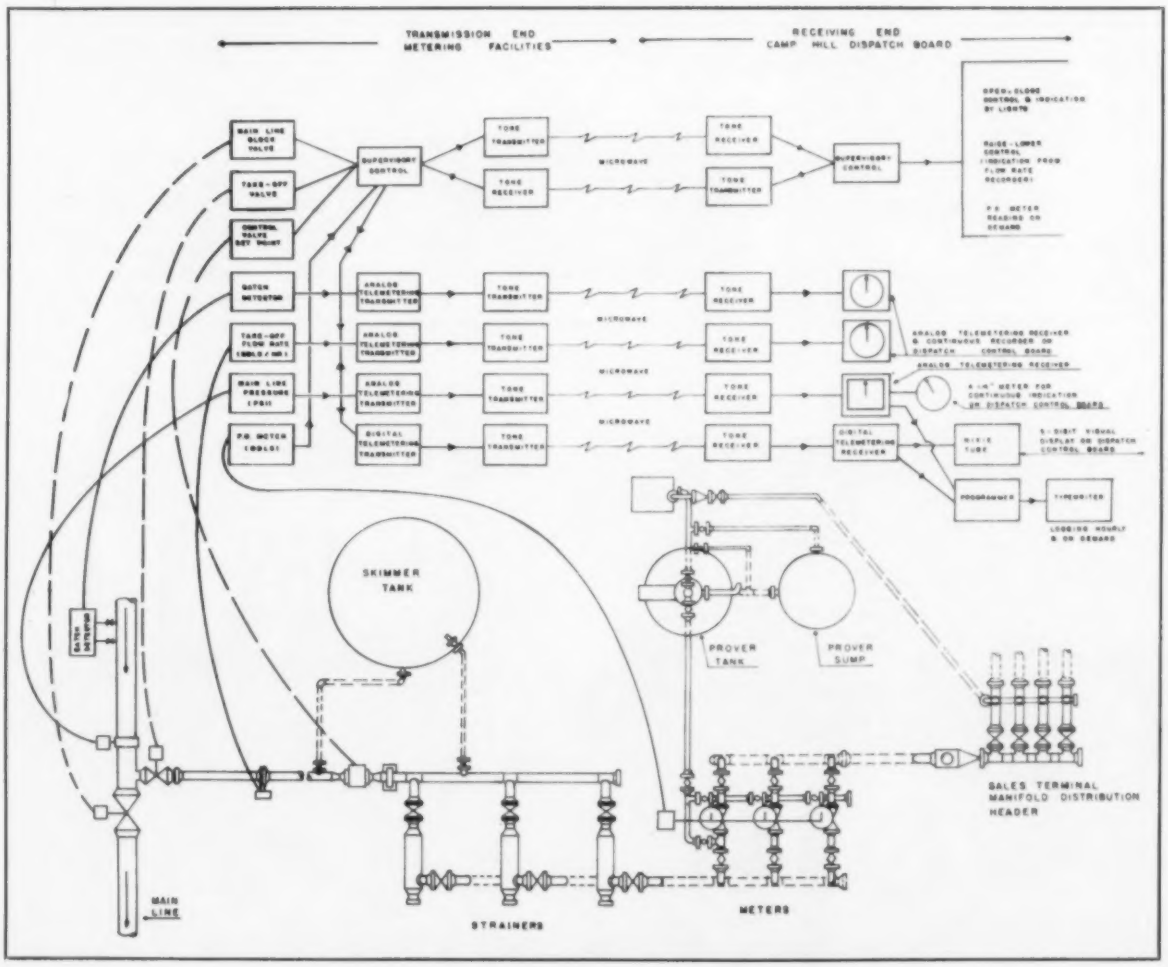


FIG. 1. Schematic of typical metering station on the Laurel system.

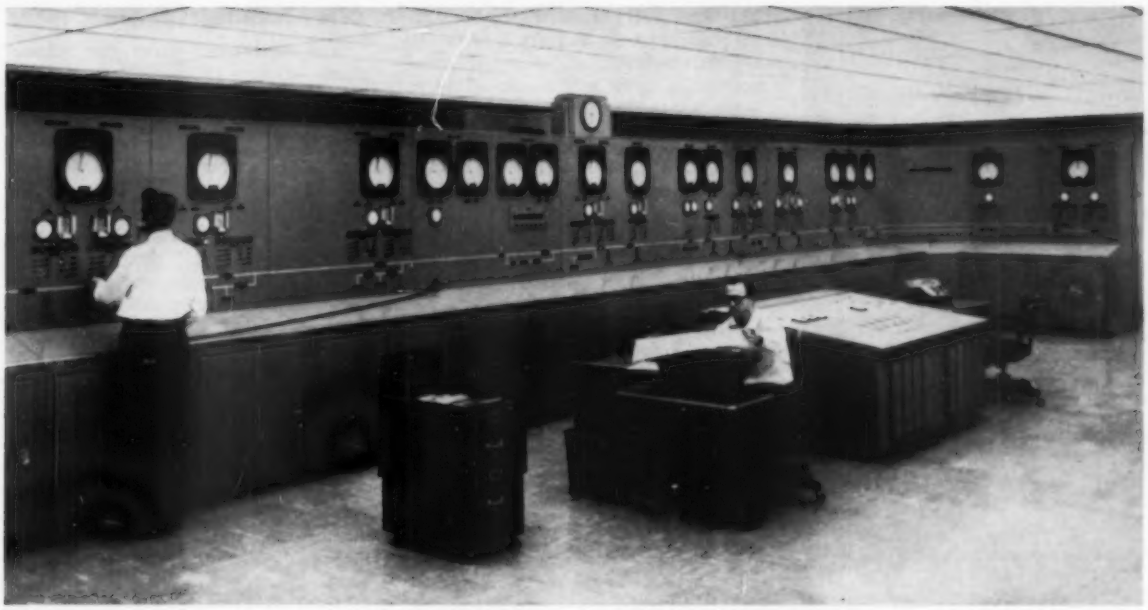


FIG. 2. Inside the pipeline's brain. Most machinery and recording instruments along Laurel Pipe Line's 447 miles are represented on this headquarter's control board. Two dispatchers read data reported from line pumping and delivery stations and operate the massive system by buttons and switches. The line itself, with switches controlling its valves, is "pictured" by the plastic strip running from the receiving station near Philadelphia (right end of board) to the Cleveland terminus (out of sight at left).

IN THE EARLY DESIGN stage of the Laurel Pipe Line system the basic psychology was utilization of time-proved equipment in a manner that would be conducive to the economical control of its pump and metering stations from one location. With this basic hypothesis, design engineers came up with a new concept in the use of equipment that is tailor-made for Laurel's particular operation.

In actual operation since the pipeline was placed onstream a little over a year ago, the system has proved to be basically sound and dependable in almost complete remote control of 21 metering stations, one pump station, and the manned automatic operation of three other pump stations.

Of primary importance is the automatic control used in scheduling 16 grades of products from three refinery delivery points so that the products may be delivered to 18 metering stations along the 447-mile system economically and with the same high degree of accuracy that could be obtained on a fully manned system.

System Features

Following are the features built into the system:

1. Ability to know the exact location remotely of the 16 grades of products as they traverse the pipeline between Philadelphia and Cleveland.

2. Ability to close or open a delivery remotely.

3. Ability to control the flow rate into a particular metering station remotely, so that maximum hydraulic efficiency and strict adherence to a predetermined pumping schedule may be maintained.

4. Ability to remotely determine main line pressures at strategic locations.

5. Ability to have complete assurance that in the event of a failure of any type that the unmanned station would either fail safe or could be operated on a standby basis.

6. Ability of the system to constantly monitor itself and give indications of its operating characteristics.

7. Ability of system to maintain, automatically, a specific set of minimum pressure conditions so that the line will remain completely packed and thus eliminate the possibility of excessive mixture between various grades of products.

Fig. 1 is a schematic of a typical metering station on the Laurel system, showing one method of bringing a portion of the above intelligence back to a central location. Fig. 2 shows the "brain" of the Laurel system on which the above information is displayed, and Fig. 3 gives a closeup view of typical metering station instruments located along the 52-ft "brain."

Referring to Fig. 3, the instrument on the left is recording flow rate in barrels per hour (top instrument), main line pressure in pounds per square inch is displayed by the middle left instrument, batch detector reading is recorded by the middle right instrument, number of barrels delivered is indicated by the lighted (nixie) tubes, readiness of station for automatic delivery is shown by the array of lights just below the nixie tubes. Position and control of the main line and take-off valve is at the bottom. All of this information is brought back to the one control location so that the dispatcher has almost complete control of this metering station as well as the 20 other stations along the line between Philadelphia and Cleveland.

A little more than a year ago the Laurel Pipe Line system between Philadelphia and Cleveland was placed in operation to handle 16 grades of refined products. Into it went a high degree of automation. Being a new system, built from the ground up, it was possible to make it something of a model in the use of automatic control equipment. How the design has worked out in actual operation is told in this article.—Editor's Note.

Making Remote Delivery

To make an unattended remote de-

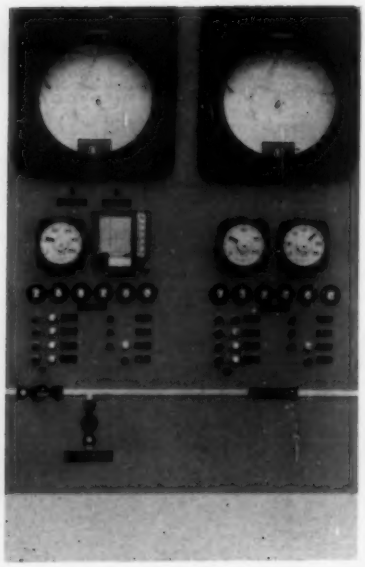


FIG. 3. Closeup of typical metering station instruments located along the 52-ft "brain."

livery, the following procedure would be set up:

1. The deliveryman would align sales department valves so that delivery would be made to the appropriate tankage, and insert delivery ticket in meter print out. After these duties have been performed the deliveryman would then leave the site and the dispatcher would be able to perform the balance of the delivery remotely except for pick up of delivery ticket.

2. The dispatcher, upon indication from the batch detector that the product to be taken off is in proper position, could then proceed with the delivery.

3. From the array of lights below the nixie tubes, the dispatcher can determine the readiness, by a station check, of the metering station for automatic operation. If the station check indicates an equipment malfunction or does not complete its sequences, it would be necessary to man the station for this particular delivery. A red light on the board indicates the source of trouble, so that the dispatcher may call the appropriate person to correct the malfunction that has developed.

4. If the above steps have been taken and the metering station has proved to be ready for automatic operation, the dispatcher would then determine his opening meter reading from the nixie tube display.

5. His next step would consist of opening the take-off valve (shown in vertical position) and close the main line block valve shown in the horizontal position, if the delivery is to be full stream. A "bleed-off" delivery would consist of opening the take-off valve only. As these valves open or close, light type indication occurs both during the travel of the valve and its position after travel has been completed.

6. As the take-off valve leaves the closed position, the flow rate in barrels per hour will be recorded on the instrument at the top of the board. Through use of the two buttons immediately below this instrument the dispatcher may raise or lower this flow rate in accordance with a predetermined schedule. This flow rate would be maintained automatically, until it has been decided that it should be changed to suit actual physical operating conditions.

7. From the visual display of pressure, during the operation performed under Steps 5 and 6, the dispatcher has instantaneous indication of the effect to the main line stream during this operation. In other words, a sudden drop in pressure would indicate that the opening is being performed too abruptly.

8. Closing of the meter station would be performed remotely in almost reverse order.

9. During a delivery, the dispatcher has assurance that he is delivering the proper, on specification, product, through the use of the batch detector reading, which is continuously recorded.

As each of the 21 metering stations brings back similar intelligence that enables the dispatcher to perform opening, closing, hourly checks, etc., the dispatcher is able to operate the system more efficiently with minimum manpower from one central location. As an additional aid to the dispatcher, meter reading and main line pressures are recorded on a typewriter hourly or on demand.

THE AUTHOR

Marlan G. Jordan, chief engineer of Laurel Pipe Line Company, received a BS degree in civil engineering from Southern Methodist University in 1950. He served a short time as a laborer with Gulf Refining Company, then was transferred to Fort Worth, Texas, as a civil engineer. In 1952 he was made a design engineer with headquarters in Houston. Was assigned to Pittsburgh, Pennsylvania, as staff engineer for the coordinator of pipelines in 1955, and assumed his present position in 1958.

Communications System

The intelligence from the remote meter stations is dependent on the communication system. It was necessary to incorporate into the design of the system features that would prevent any adverse operation of the system should a failure of the delivery equipment or communications occur.

In the event of a commercial power failure, emergency generators were provided with sufficient capacity to supply power for the communications link and other associated equipment necessary for automatic unattended operation.

If there should be complete communications failure, and the dispatcher has no indication of intelligence from a metering station, the delivery could be continued without supervision from the dispatcher if the delivery is not on a full stream basis. These things would happen:

1. A set-stop counter would completely shutdown the metering station when the proper number of barrels was delivered.

2. A pressure switch would automatically shutdown the station if abnormal pressures were experienced.

3. A mechanical sampler would take a composite physical sample of the product being delivered.

4. The set point control of flow would maintain a flow into the station at the point it was last set.

5. In the event of a malfunction in the control of flow rate the metering station would fail in the closed position.

6. The emergency generator would circumvent any commercial power failure.

At metering stations where there is likelihood of a full stream delivery, pressure override is installed, so that line pack will be maintained at a safe level. This feature also is built into the suction pressure of Mechanicsburg, Duncansville, and Aliquippa stations.

The design of these metering stations has proved to be most successful in actual operation and has required little modification. Dependability of the equipment is 95 percent or above at the present time with expected final reliability of 97 percent or above.

Design and operation of both the remote unattended pump station at Duncansville and the three manned automatic stations at Booth, Mechanicsburg, and Aliquippa are more or less standard throughout the industry and have proved to be dependable in actual operation. ★ ★ ★

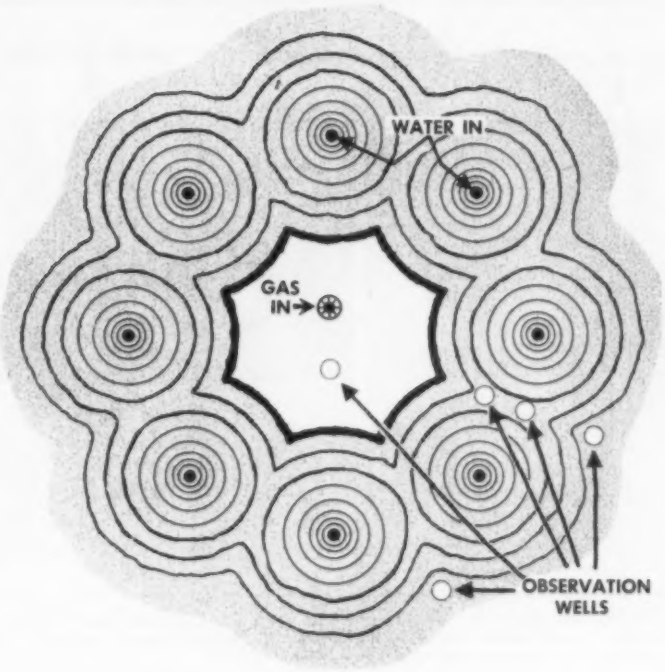


FIG. 1. Experimental storage "bubble" at NI-Gas' Station 147 is explained by diagram. Eight water injection wells have been drilled around a 1700 ft diameter circle. Water injected will connect to form a continuous "wall" as shown by the shaded area. Air (in place of gas) will be injected in the center of the area. Numerous observation wells will allow engineers to check the experiment's progress.

GAS "BUBBLE" STORAGE

Wall of water used to seal underground container topped by flat cap rock may revolutionize storage method

DEAN HALE

A BUBBLE OF NATURAL GAS beneath a flat cap rock, surrounded by a wall of water, may be the method of the future for underground storage if a revolutionary experiment underway by Northern Illinois Gas Company proves successful.

Admittedly, the idea is still in the experimental stages, but engineers and geologists studying the method see no reason that it won't work under proper conditions.

What NI-Gas' engineers are doing seems quite simple: They've drilled eight water-injection wells in a circle around a gas-injection well. Into the wells on the periphery, they will inject enough water to form a connecting "wall" of water beneath the cap rock structure. This "wall of water" will provide a gas-tight seal that will completely enclose the "container" in the middle into which the gas can be injected.

In the experimental stage, the NI-Gas engineers are using air instead of gas, but the results will be the same. The air forced into the center of the container is expected to form a "bubble."

Why It Works

Several conditions are necessary to achieve successful application of the new gas storage theory.

First, the cap rock that will serve as a "lid" to the container must be a dense material—such as compressed shale or other impermeable material—that will not allow passage of a fluid (a gas or a liquid).

Beneath the cap rock there must be a sandstone of sufficient porosity to serve as storage space.

Also important are permeability of the sandstone and depth of the formation, which determines to some extent the static pressure in the storage area.

Formation Requirements

The best type of sandstone for a "bubble storage" project is one that has a preference for water—rather than a preference for oil. This is called a "preferentially water wet" formation and is a characteristic of sandstones that are deposited in a marine environment. Even if the formation contains no "connate water" (water that originally filled the pore spaces in the sand and which may have migrated elsewhere) the sandstone has a higher attraction for water.

With a sandstone such as this beneath the cap rock, it is necessary to inject only enough water to saturate the zones surrounding the wells (located on the perimeter of the proposed storage area) so that these zones will connect and form the circular-shaped barrier.

At the site selected by Northern Illinois, the St. Peter sandstone used as

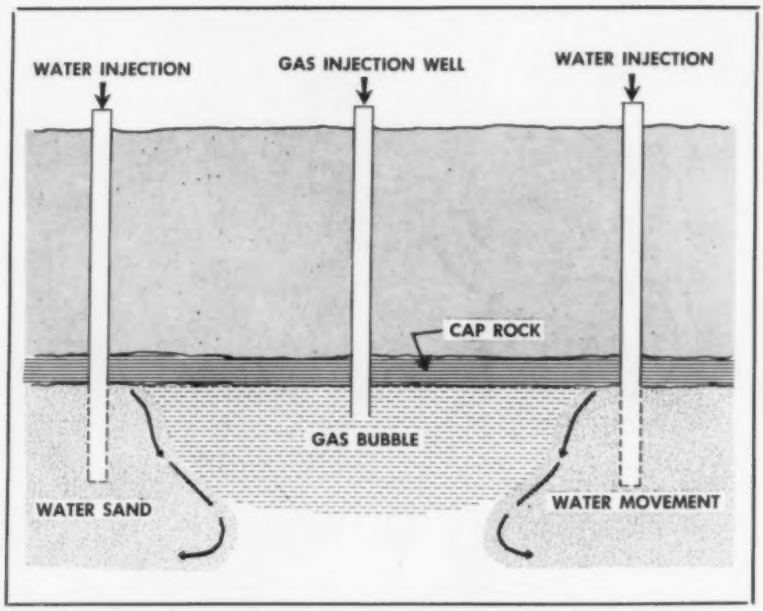


FIG. 2. Bubble storage under a horizontal cap rock. Cross sectional view illustrates how "wall of water" would confine gas inside the "container." Capillary pressure of water in sand pores would prevent gas movement.

the storage formation is filled with water, and is approximately 150 ft thick.

Overlying this sandstone is a dense limestone — part of the Trenton structure — which serves as the "cap rock."

The water injection wells are drilled to approximately 1000 ft below the surface. Into these wells, sufficient water is injected to increase the hydrostatic pressure from 50 to 100 psi above the normal static pressure of the formation — which is approximately 450 psi.

Beneath the sandstone formation is another thick rock layer, composed of limestone and shale.

The water injected into the 8 wells around the circle is expected to form a series of connecting zones and seal off the inner chamber.

Gas injected in the center is expected to spread downward and outward, forming a mushroom-shaped bubble, similar to that shown in Fig. 2.

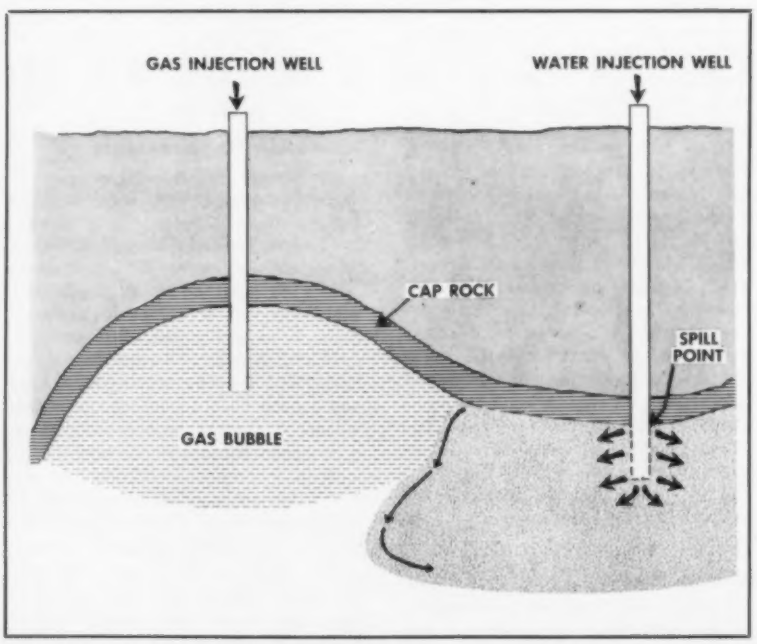


FIG. 3. Wall of water on horizontal side of a cap rock structure with three downward-sloping sides would make useful storage container out of a dome that would otherwise be abandoned. Many such structures have been found.

Where It Can Be Used

Northern Illinois, looking ahead to future gas demands on its system, is seeking more underground storage reservoirs. There is a shortage of "ideal" storage areas, consisting of a dome-shaped cap rock (similar to an inverted saucer) over a sandstone formation into which gas can be forced and held under pressure.

Quite often, in their search for such formation, NI-Gas engineers have found a cap rock with three downward-tilting sides and one that is horizontal. Gas forced into such a structure would escape from the horizontal side.

If this horizontal side could be sealed-off with a "wall of water," then the resulting reservoir would hold gas as well as any natural dome.

Similarly, a tight cap rock that is completely horizontal could also be used if a circular wall of water could be put under the cap rock "lid."

The tests now underway at NI-Gas' Station 147 at Matteson, east of Joliet, will also provide answers to such questions as relative costs of the new method, volumes of water required, and methods and rates of injecting water.

If successful, the experiment will make possible the use of flat storage reservoirs for underground storage of natural gas . . . and is expected to be of interest to many utilities located in areas where natural storage formations just aren't available.

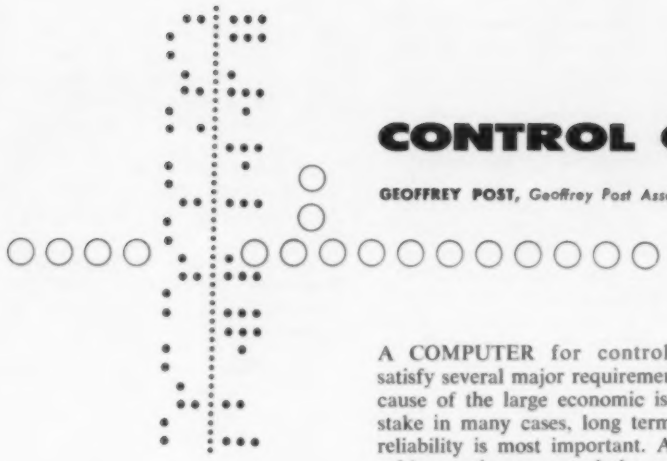
Ends Justify Means

Like most gas distribution companies, Northern Illinois Gas is faced with growing demands on its system. On cold winter days, customer demands greatly exceed available supplies. In the summer, supplies greatly exceed demands.

Ideally, the company can store gas in the summer and make it available in the winter for "peak shaving" purposes. Underground storage is the best method for accomplishing this.

NI-Gas anticipates that it will need several new storage reservoirs in the next five years in close approximation to its northern Illinois service area.

If the present experiment is successful, these will be easy to find. ★ ★ ★



CONTROL COMPUTING

GEOFFREY POST, *Geoffrey Post Associates, Los Angeles, California*

Part 1:

An introduction to computer types . . . their capabilities, reliability, and maintainability

A COMPUTER for control must satisfy several major requirements. Because of the large economic issues at stake in many cases, long term ultra-reliability is most important. Also, to achieve optimum control, the computer must be capable of resolving and correlating a vast amount of dependent and independent control data. Without optimum control, economic justification of computer control may be improbable.

Further requirements include economy, simplicity of operation, and ease of maintenance.

The objectives in optimum control are not hard to generalize. A simplified statement of these objectives is that it is required to produce the best quality and largest quantity of those products most marketable for the least expense. Thus, an optimization problem evolves that is based on a complex of operations whose quantitative inter-relationship is known only vaguely at present.

Previously, control was approached on a "best-that's-available" basis in the following manner: Adjustable automatic controllers were placed at strategic positions in the process configuration. A human correlator, the operator, was responsible for starting the process toward a designated state of operation. Control criteria was the experience of the operator and his associates plus some furnished concepts of control stability. Upon establishing stable operation, which usually means elimination of oscillation or cycling, an operating band was defined and the process went on stream.

This approach left much to be desired because the operator is limited as a correlator, and even the experienced operator often is unaware of the relative weights of the many variables upon the output product.

Control of system dynamics was thus largely art and experience with very little science.

The Analog Computer

To date, only analog computing equipment has been used extensively in on-line control systems. Because of certain basic limitations of analog equipment, however, the degree of control has been restricted.

We are interested ultimately in a sophistication of control that will obtain a substantial improvement in things like product quality, rate of production, and operating costs compared with what is obtainable with present control methods.

Furthermore, the complexity of control should be limited only by the nature of the process itself and the control instrumentation. Such demands inevitably indicate the use of digital computers. Why this is so will be brought out in the discussion that follows.

An analog computer is capable of performing (with limited accuracy) the operations of addition, subtraction, multiplication by constants, integration, and generation of a function of a single variable. However, the analog computer may either be inadequate or incapable of meeting other important requirements of a large-scale control system. It is not suitable for operations like the multiplication or division of variables, data correlation, extrapolation, etc. It is also deficient in its capacity for logical operations. Finally, it does not provide adequate data storage facilities.

An analog machine may not be adequate even for relatively simple computations if there are a large number of them, or if non-linear characteristics are present. In both cases one is faced with problems of obtaining adequate accuracy and reliability.

In the first case, representing a system with many components, the accuracy of each analog element must be high even though the overall system

accuracy requirements are low. This is because system accuracy is a cumulative function of component accuracy; however, there is a definite limit to the accuracy obtainable from individual analog elements. In the second case, non-linear elements must be used, and these are especially difficult to design with sufficient accuracy.

Costs. From the preceding remarks, it is apparent that a large analog system tends to be both unreliable and costly. For relatively simple computations, analog equipment is less expensive than digital, but beyond a certain minimum degree of complexity the relative efficiency of the digital machine continues to increase. This is because in an analog machine the amount of equipment needed is roughly proportional to the computing load whereas in a digital machine this is not so.

Because analog computation requires the design of many specialized components, it may be said, in general, that the costs of systems engineering for an analog computer will be higher than that for a digital machine. Also, future modifications will be more expensive. This is because changes in the control function may require additional computing elements and perhaps even the introduction of new specially designed ones. In a digital computer, changes in control functions usually can be accommodated by changes in the stored program.

In comparing costs, one must recognize that a basic digital installation will provide a number of facilities in addition to the computations required for control, e.g., alarms, data storage, logging operations, etc. In an analog installation, a special comparator circuit would have to be added to obtain an alarm; the inclusion of even a relatively small amount of data storage (compared to that in a digital machine) would add considerably to the cost.

An analog computer can receive information from process variable sensing devices, and transmit information to actuators without the need for analog-to-digital conversion devices. However, digital sensing devices are becoming more common and digital logging is also gaining prominence. Also, in certain special purpose incremental digital computers, the equipment needed for analog-to-digital conversion can be simplified to the point where it is comparable to that required for transmitting an analog input to an analog computer. As a result, the advantage of an analog machine in respect to requirements for data conversion is decreasing.

Computational facilities. Often the output signal of a transducer is a non-linear function of the variable being measured. In a digital computer, it is a relatively simple matter to store calibration data, on the basis of which required corrections can be applied to the sampled data.

There is an optimum location of the set point of a given variable if the effects of other variables are neglected. In general, however, a theoretically optimum setting for one variable may adversely affect other variables. If the locations of all the various optimum points lie within the permissible operating ranges, a computer can, by correlative computation, keep the process operating continuously with optimum performance even though material characteristics and environmental conditions are changing.

In an analog computer, a simplified correlation scheme is possible wherein the intersection of the best slopes of several parameters is determined. An analog computer, however, is not well suited for complicated correlation or data processing, and would require an impractical amount of equipment for these functions. This means the type of control sophistication possible with present analog machines is greatly limited.

As far as the speed of computation is concerned, both analog and digital computers are adequate for supervision of minor loop controllers.

Reliability. In general, it may be said that the more equipment involved the more unreliable the system. For complex control systems, the digital machine is superior to the analog as far as reliability is concerned. Even for relatively simple control jobs, a small incremental digital computer can be more reliable than an analog machine.

As far as computer operation is concerned, complete failures can be detected readily in both analog and digital computers. The analog computer, however, is more prone to faulty operation from marginally operating components. Also, the analog computer cannot check itself economically or even provide means to simplify trouble-shooting by supervising personnel. The latter situation occurs because individual errors are independent and do not necessarily accumulate in a predeterminable manner.

A computer should be capable not only of checking its own operation, but also of diagnosing troubles in the process and its controllers as well. It is a relatively simple matter for either an analog or digital computer to check on whether variables of the process are within prescribed limits. The digital computer, however, has computational and logical facilities that can provide anticipatory indications of trouble. For example, it can search for dangerous trends, and the simultaneous occurrence of events that imply trouble.

THE AUTHOR

GEOFFREY POST was graduated from the University of California with a BS degree in electrical-mechanical engineering; did work on his masters at the University of Pennsylvania and UCLA, receiving his MS degree from the latter, in computer technology and automatic control. Has spent 11 years as a professional engineer in the fields of automatic control, servo-mechanisms, analogue and digital computers. Served on engineering staffs of Electronic Engineering Company of California, Allen B. DuMont Laboratories, Servomechanisms, Inc., General Cybernetics Corporation, Litton Industries, and Genesys Corporation (now Information Systems, Inc.). Was vice president, engineering, of Genesys when he entered consulting work recently as Geoffrey Post Associates. Also, was 5½ years in military electronic service and did 5 years of university level teaching at universities and technical schools. Holds five patents. Is member Institute of Radio Engineers and American Ordnance Association.

The Digital Computer

The control of a process requires that certain physical entities must be moved, switched, or otherwise directed by physical input signals. The nature of the quantities being controlled will determine the required speed and accuracy of response to the control signals. The inputs to the computer are,

typically, continuous physical quantities such as temperature, pressure, rate of flow, etc. Each of these quantities can be converted to some form of digital representation by an analog-to-digital conversion scheme, and then entered into the computer at prescribed intervals.

In such a control problem, the same computation is repeated for each entry of the sampled input data. The outputs of the computation appear first in the form of a digital numerical representation. By use of a digital-to-analog conversion scheme they may be converted to continuous physical signals like shaft positions and voltages. The latter signals drive actuators that, in turn, control the process.

Input and output conversions represent a major part of a computer control system. In general, they tend to be of comparable complexity, regardless of whether the computer is of the arithmetic or incremental type, if the quantities are entered and read out in a binary weighted representation. Such a representation is necessary for use with an incremental machine only when a "no loss of reference" feature is a requirement. Otherwise, the conversion problem can be simplified when an incremental machine is used.

A typical control application might have the following requirements: Smoothing and prediction, storage of the values of process variables for the preceding time interval, t, storage of calibration data, storage of safe limits of variables, integration, data correlation, polynomial function generation, solution of differential equations, system tests with generation of alarms when required.

There are two principal types of digital computers available; the so-called arithmetic, absolute, or integral transfer type of computer, and the incremental transfer type of computer. Both types may be classified as general purpose or special purpose according to whether they are designed for general or special application. The tag, "general purpose computer," has been commonly used, however, to refer to any type of integral transfer computer.

In the discussion that follows, it is assumed that we are referring to special purpose computers intended primarily for control. A comparison of both integral and incremental transfer machines will be made in order to determine their relative merits as control computers. The criteria on which they will be compared are speed, logical and mathematical capabilities, reliability, and maintainability. Cost implicitly enters the picture.

Speed. There are two basic types of speed requirements for a control computer. First, problem solutions must be generated at a rate adequate to keep pace with high-frequency changes in the input signals. This calls for frequent recomputation; i.e., a high computation frequency. This frequency determines the bandwidth of input signals to which the computer can respond. In practice, this bandwidth is about one-eighth to one-fourth of the computation frequency. Also, the initial solution of a new problem should be completed without too great a time lag. This requires that it be possible to generate large changes in a variable during each computation cycle. This is necessary if the computer is to be able to progress promptly from any given state to the state demanded by a new condition. The time required to complete this action is usually referred to as slewing time.

A comparison of the two principal types of digital computers in respect to both speed requirements is given below:

Computation frequency. It is difficult to make a direct comparison of the computation frequency of incremental and arithmetic computers except for specific machines, a specific problem, and specific programs for the solution of the problem. A useful estimate can be made, however, by considering the times required to execute certain basic operations by two comparable machines, say two serial, synchronous machines with a magnetic drum main store:

	Word times to perform an operation	
Operation	*Incremental*	*Arithmetic*
Add, subtract	1	1 + Access time
Multiply	2	n + Access time
Divide	4	n + Access time
Sine, cosine	1	Function of numerical approximation
Integrate	1	Function of numerical approximation

A usual value of "n" is somewhere between 15 and 20. Even for minimum access programming, access time may average between 5 and 10 word times. There are many programs that may be used for generating the *sine* or *cosine*. Such programs may involve 20 to 30 additive or transfer operations and, say, half a dozen multiplications. It appears then that, for a computation involving continuous variables, an incremental machine would be about an order of magnitude faster than an arithmetic computer.

An incremental machine of the type described can generate on the order of 100 to 200 solutions per second, and the arithmetic computer about 10 to 20 solutions per second. Therefore, the incremental computer would be satisfactory in a control system requiring a bandwidth of 0 to 25 or 50 cps, whereas the arithmetic machine would not be adequate above 2.5 or 5 cps.

Slewing time. Starting from any state, an arithmetic computer can generate a first solution in one computation period. The time required for a first solution with an incremental machine depends on both the gap to be bridged, i.e., the magnitude of the variable change, and also on the scale of the variable to be changed, the scale factor determining how many single increments must be generated.

The slewing time advantage of the arithmetic machine follows naturally from its capability to alter a variable by one or more increments, up to the numerical capacity of the machine, on every computation cycle. This allows it to establish completely new values of all quantities in one cycle of computation.

A reasonable inquiry is whether an arithmetic machine can be simplified at the cost of some increase in slewing time, and also whether the slewing time of an incremental machine can be appreciably improved by a moderate increase in equipment complexity. In regard to the former question, no such design has appeared, and may be considered unlikely. In regard to the latter, modifications can be made to the basic incremental machine that will improve its slewing time. The increase in the machine's complexity depends on the sophistication of these refinements.

To summarize, the incremental machine is rate limited, whereas the arithmetic machine is frequency limited. Although the incremental machine can generate many increments per second, the totality of these changes represents a small quantity. The arithmetic machine can generate large changes in a quantity per computation, but the frequency with which it can perform these computations is limited.

Logical and mathematical capabilities. The computer should be capable not only of performing different com-

putations, but also of scheduling them for overall supervisory control. It should be capable of calling in different individual computations as required, by being equipped with the facility to make decisions based on logical considerations. In some cases, these different computations must be made available quickly. This may be achieved by recourse to either of the following general procedures:

1. Simultaneously computing all functions that may be required.

2. Computing at any given time only those functions then required, but providing the machine with the capability to initiate a new computation promptly on demand.

Practical differences in the capabilities of arithmetic and incremental types of machines for three different classes of operations are enumerated below:

Computations on continuous variables. The incremental machine requires less time and equipment to perform routine repetitive algebraic and trigonometric operations on continuous quantities. This is a fundamental advantage that can be capitalized on in control systems where the quantities are continuously variable and limited. The arithmetic computer cannot capitalize on the continuous nature of inputs from a control system, since its logical organization is such that, in any given cycle, the computations it performs do not utilize information generated in the preceding cycle.

Decision making. Because new values of all quantities can be obtained in a single cycle, the arithmetic machine requires only one computation period to start on a new computation. The incremental machine is slow in initiating a new computation for the following reasons. Before it can drop an old computation and begin a new one, i.e., go from any given state to an arbitrary new state, each quantity within the computer must work its way to the new value, one increment at a time.

It is emphasized that the incremental machine has no intrinsic difficulty in making a decision, but only in implementing it; i.e., getting started on the path called for by the decision. As already indicated, there are ways to overcome this difficulty. An obvious but uneconomical procedure would be to maintain all possible computations simultaneously in the computer, and implement the decision by switching to different outputs.

There are also other procedures. For example, anticipatory circuits may be included, in closed loop systems, which make both the function and its time rate of change available, and effectively improve response time by giving error rate as well as error position control.

Another procedure for improving the response is to use a multi-mode digital servo where the system operates for a small range about the null point in a linear manner and outside of this range operates non-linearly.

Data processing. In addition to its normal computational and logical capabilities, the arithmetic type of computer is also capable of a variety of general data processing operations. It can sort and collate data, although this is a very time-consuming process for a machine without special facilities for these operations. Also, of importance in certain applications, is its capacity for processing noisy data of low correlation.

The incremental machine is not as well suited for problems of logical analysis, and sorting and collating of data. Basically, this is because these operations usually involve large changes in the contents of registers in each cycle of operation. Also, the basic operational element of the incremental machine is not suited for processing noisy data.

Table 1.

Type of Machine	*Advantages*	*Disadvantages*
Analog	1. "Parallel" operation in solving a problem, therefore fast in response	1. Components are inflexible and usually single purpose
	2. Simple input-output communication with problem	2. Accuracy limited
	3. No ultra-high speed components in comparison to overall loop response	3. Number of components increases exponentially with problem complexity thus raising initial operating and maintenance costs and decreasing reliability
	4. Inexpensive and fast to program	4. Complicated error analysis for checking overall operation, i.e., hard to find mistakes or failures
	5. Gives a "feel" of the problem in on-line application	
Digital (General purpose or arithmetic)	1. Versatile components	1. Enormous number of components that "overwhelm" job
	2. Accuracy unlimited	2. Serial operation requires high operational speeds raising initial, operating and maintenance costs and decreasing reliability
	3. Individual components extremely reliable	3. Complex input-output equipment
	4. Simple to check failures in machine or problem	4. Complicated to program and little problem "feel"
	5. Simple to expand complexity of problem without costly modifications in the computer itself	
Special Digital (Special purpose, incremental or memory-efficient)	1. All of the above advantages of analog and general purpose digital	1. None of the disadvantages of either analog or digital computers listed above
	2. Extremely efficient in non-linear function generation and non-linear differential equation solutions as control equations, i.e., it is inherently a "dynamics" computer	2. Limited practically to system slewing speed requirements of less than 10 cycles per second, i.e. any system variable changes faster than 0.1 second costs extra to handle
	3. Tremendous system reliability attained through time sharing of large number of components	3. Inefficient and inflexible to do large scale data processing, such as accounting type functions or large groups of algebraic equations
	4. Low in cost for complexity and sophistication of control capability	4. Complicated to check logically because of time sharing forcing checking by component substitution, etc.

Computing

Reliability and maintainability. Because of the large economic losses that would be incurred by shutdowns of a process control operation, reliability of equipment is of prime importance. The system design should be such that failures are minimized and capable of prompt repair. The frequency of errors produced by malfunctions must be reduced and their effect controlled. An important means for error control is the use of programmed checks. Such checks can be incorporated readily in the program of an arithmetic computer.

Basically the reliability of the system depends on good electrical and mechanical design. Straightforward and uncomplicated logical design, the availability of test programs, and special test facilities all contribute to good maintainability. Reliability and maintainability will each be discussed, in turn.

Reliability. One measure of reliability of a computing system is the time interval over which the system operates satisfactorily. There are essentially two factors that affect the reliability of a digital computer, namely, malfunctions and failures. The malfunction is a transient disturbance that produces an error which may or may not propagate. The failure results from a permanent change in the characteristics of a component such that it no longer satisfies the demands of the circuit in which it functions.

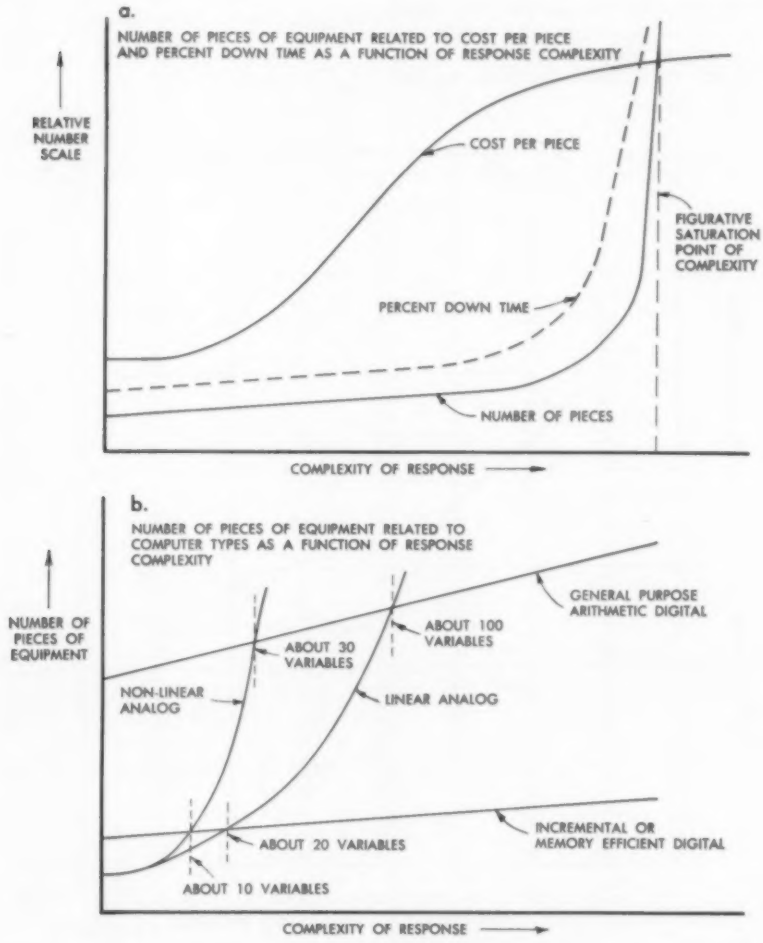
The incremental machine has fewer failures simply because it has fewer components. Also, it has fewer malfunctions; however, the errors from these malfunctions may have widespread effect. First, because of the large degree of time sharing usually employed. Second, because the effect of an error may persist for a long time. This is because new computations always utilize old data. Some percentage of the malfunctions may cause only negligible trouble, however. This would be the case if only one increment were affected, or the value of a relatively insignificant variable altered.

In the arithmetic computer, most malfunctions cause only a temporary disturbance because, in general, the computations in one period are independent of those in the preceding period. It is only when the problem being solved is such that data is retained from one period to the next that errors are not removed promptly.

It appears then that the incremental machine has the advantage in respect to failures, and that the two are comparable in respect to the number of computations invalidated by malfunctions.

Maintainability. Whereas reliability is determined by the rate at which faults are generated, maintainability refers to the ease with which an existing fault may be found. The maintainability of an incremental machine is reduced by complexities of logical design, usually centering about a greater use of time-sharing. However, the degree of time-sharing employed can always be reduced at the cost of additional components. Also, additional equipment can be added to the basic incremental machine to provide improved error-detecting capabilities.

The maintainability of an arithmetic machine is adversely affected by its large number of components, but is aided by the following: (1) The availability and relative ease of interpreting step-by-step operation; (2) special program control features as, for example, a break point facility, and (3) diagnostic and test programs.


a.
NUMBER OF PIECES OF EQUIPMENT RELATED TO COST PER PIECE AND PERCENT DOWN TIME AS A FUNCTION OF RESPONSE COMPLEXITY
RELATIVE NUMBER SCALE
COST PER PIECE
FIGURATIVE SATURATION POINT OF COMPLEXITY
PERCENT DOWN TIME
NUMBER OF PIECES
COMPLEXITY OF RESPONSE
b.
NUMBER OF PIECES OF EQUIPMENT RELATED TO COMPUTER TYPES AS A FUNCTION OF RESPONSE COMPLEXITY
NUMBER OF PIECES OF EQUIPMENT
GENERAL PURPOSE ARITHMETIC DIGITAL
ABOUT 100 VARIABLES
ABOUT 30 VARIABLES
NON-LINEAR ANALOG
LINEAR ANALOG
INCREMENTAL OR MEMORY EFFICIENT DIGITAL
ABOUT 20 VARIABLES
ABOUT 10 VARIABLES
COMPLEXITY OF RESPONSE
FIG. 1.

Summary

The overall comparisons of analog, digital, and incremental digital computers are summarized in the accompanying table and charts. Table 1 outlines the advantages and disadvantages of analog, general purpose-digital, and incremental-memory efficient digital computers for control purposes. The two charts shown in Fig. 1 summarizing price, number of pieces required, cost per piece, percentage of down time, and relative scale of analog, digital, and special digital devices as a function of problem complexity. The latter term refers to number of variables and the form of their relationships. ★

(In Part 2 the author will discuss specific applications of the different types of computers to pipeline use.)

MUFFLER DESIGN

SILENCING TWO-CYCLE TURBOCHARGED ENGINES

EDGAR S. STODDARD, *Vice President, Universal Silencer Corporation, Libertyville, Illinois*

WITH the advent of the two-cycle turbocharged engine, the conventional baffle or non-tuned chamber silencer used on its cousin, the four-cycle turbocharged engine, became obsolete due to the exhaust system pressure drop limitations required by the engine builders for proper engine performance.

Initially, exhaust silencer pressure drops of 6 in. of water were allowed, but with the demand for improvement of engine performance, this figure dropped until it reached the presently generally accepted maximum level of 1½ in. of water.

Using the conventional baffle or non-tuned chamber type silencer to meet these low pressure drop limitations required that the silencer manufacturer design silencers having an exhaust velocity of approximately 3000 ft per min compared to 8000 to 10,000 ft per min normally used on all other engines. Because of this low velocity, the silencer not only became extremely large physically, but was too expensive. These problems could be overcome only by abandoning the old reliable design and developing a new type of silencer having a low pressure drop associated with a high exhaust velocity with a consequent reduction in overall physical size and cost.

The parameters for a practical exhaust silencer for the two-cycle turbocharged engine are reduced to:

1. Low pressure drop,
2. High exhaust velocities,
3. Physical dimensions,
4. Maximum silencing with ability to reduce silencer performance to two or three classifications.

For practical purposes the silencer pressure drop and the exhaust velocity are functions of each other and therefore must be considered together.

From the basic engineering principles of the kinematics of air flow, it is a known fact that the minimum pressure drop for any velocity can be accomplished with a straight section of round duct. Terminating this duct in a chamber will change the flow characteristics of the gas and thereby increase the pressure drop. With this in mind, the natural approach to this problem is to design a silencer having a continuous straight-through tube or conduit.

Referring again to the basic laws governing the friction of gases in straight lengths of pipe, the following has been established.

1. Resistance or pressure drop varies nearly as the square of the velocity,

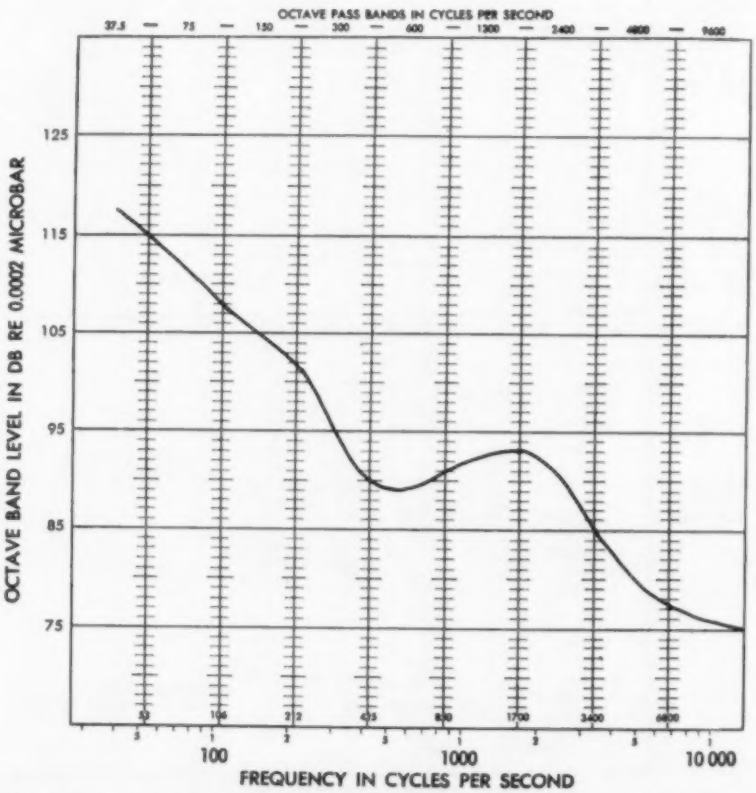


Fig. 1. Typical unsilenced exhaust noise level 10 ft to side of exhaust outlet for large two-cycle turbocharged gas engine.

2. Resistance or pressure drop varies directly as the density of the gas,

3. Resistance or pressure drop varies directly as the area of contact between the gas and the wall of the conduit.

Expressing these laws in algebraic form, the pressure drop through a length of straight conduit becomes:

$$\text{Pressure drop} = \frac{2\ FLDV^2}{dg}$$

Where:

Pressure drop is inches of water

L = length of silencer, ft

D = density of gas, lb per cu ft

V = velocity of gas in pipe, ft per sec

d = diameter of pipe, ft

g = acceleration of gravity, ft per sec

F = friction constant of internal silencer tubes

With these basic laws in mind a silencer designed with a straight-through conduit is the only one that would meet all parameters previously established. Tests demonstrated that for smooth pipe with gas flowing at 100 ft per sec and containing a pulse of ± 1½ in. of water, the pressure drop became:

$$PD = 0.0148 \frac{L}{d} h$$

With the tube perforated or slotted, the friction along the walls of the conduit increased due to turbulence and the resultant pressure drop increased to:

$$PD = 0.032 \frac{L}{d} h$$

Where h = velocity pressure, in. of water.

To further reduce the pressure drop due in the straight-through type silencer, diverging and converging nozzles have been installed in these silencers now in the field. The theory that the pressure drop is reduced by installing these devices has not proved completely effective where the pressure drops are low initially. Test data on some installations show no change in overall pressure drop, and in other installations, where a change in pressure drop was present, there was no change in scavenging air pressure or turbocharger speed. Additionally, the resultant physical size of the silencer was not reduced sufficiently to offset the added cost of the nozzles.

Tests have been conducted on silencers that required the exhaust gases to turn 90 deg prior to leaving the silencer. A simple turn such as this increases the pressure drop across the silencer to at least twice that developed in the straight-through type silencer.

The common belief that the turbocharger produces most of the noise in the exhaust of two-cycle engines is a common misconception. The major noise components in the exhaust and intake noise spectrum are the low frequencies usually below 100 cps.

Low frequency pulse is major source of noise. The two-cycle turbocharged engine has a predominate low frequency pulse when operating without an exhaust silencer, as shown in Fig. 1. This is common with this type and other large industrial engines, and the energy in this low frequency pulse is sufficient to cause window breakage at

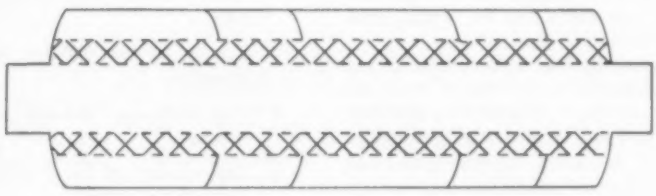


Fig. 2.

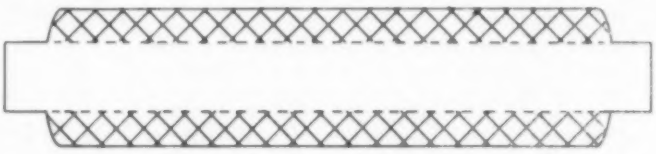


Fig. 3.

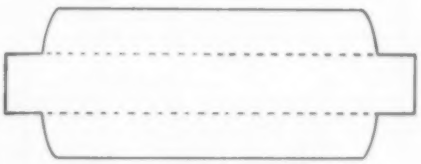


Fig. 4.

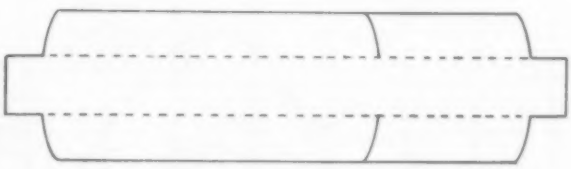


Fig. 5.

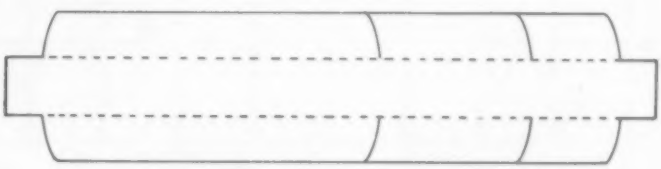


Fig. 6.

a distance of 100 yards or more from the exhaust outlet. It causes flat surfaces to vibrate and walls of houses to shake.

This misconception as to the audio spectrum of the exhaust noise has led to an erroneous belief that adequate silencing can be achieved by installing mufflers of the absorption type shown in Fig. 2 and 3. This type of silencer is extremely effective in reducing high frequencies but does not perform well at low frequencies. In some instances this design may tend to amplify very low frequencies.

Having investigated the physical properties of the conduit that directs the gas flow through the silencer, the major parameter left for investigation is the ability to silence.

Again referring to basic engineering techniques of muffler design, there are two basic types of mufflers commonly used in industry: (1) Absorption type and (2) non-tuned chamber type. Each of these types of mufflers has its own particular performance characteristics, and although they overlap in some areas, they are not usually interchangeable. There is also a third type of silencer that falls into a special category and that is the tuned chamber type designed for specific applications.

With a knowledge of the general unsilenced noise spectrum from two-cycle turbocharged engines, noise reduction tests on the silencers shown in Fig. 4, 5, and 6, which incorporated the features of a resonator or tuned chamber type muffler and the non-tuned chamber type muffler, revealed that response of the chamber was a function of:

1. Velocity of sound in the exhaust gas,
2. Volume of the chamber,
3. Cross-sectional area of the conduit,
4. Length of the conduit in the chamber,
5. The perforated pattern in the conduit,
6. The velocity of the gas flowing through the conduit.

Equating these factors, the cut-off frequency for a chamber can be determined. This approach allows the silencer manufacturer to design a muffler that will attenuate the undesirable noise components and to provide various degrees of silencing.

Comparative performance. Comparative tests have been conducted on three designs of silencers suggested for silencing the two-cycle turbocharged engine. Namely, they are first, the straight-through design without acoustic absorbent material, as shown in Fig. 5; second, the straight-through design with acoustic absorbent material and resonator sections, as shown in Fig. 2, and third, an acoustic absorption type silencer containing a 90 deg change in direction of flow.

The straight-through design without any acoustic absorbent material provided the best overall silencing, primarily because it accomplished more attenuation in the low frequency range, as shown in Fig. 7. Despite the fact that the attenuation of the higher frequencies was not as great with this design as with the acoustic absorption type silencer, they were attenuated to the point where they were masked out by the residual low frequencies. The objective here is to omit the use of expensive acoustic absorbent material when its effect cannot be determined by the ear or a sound level meter. The third design containing the 90 deg turn was the poorest silencer of the three and was unacceptable because of its inherent high pressure drop.

The use of acoustic absorbent material in silencers used on two-cycle diesel engines is objectionable because it loads up with lube oil picked up by the exhaust gas and may become a fire hazard.

Intake silencers important on many installations. Silencing the exhaust of the two-cycle turbocharged engine does provide adequate reduction of the ambient noise so that station personnel can live with their jobs. For stations located adjacent to residential areas, however, it is important to consider intake silencers. Tests indicate that the noise from the unsilenced intake to the engine was only 10 db lower than the unsilenced exhaust. It is believed that the intake noise level would be more nearly equal to the exhaust noise level if the intake air filter were removed.

With similar pressure drop limitations imposed on the intake silencer, adequate silencing can be achieved by installing a muffler similar to that used on the exhaust. Here again the muffler manufacturer having adequate control over his product can provide the user with the degree of silencing required.

* * *

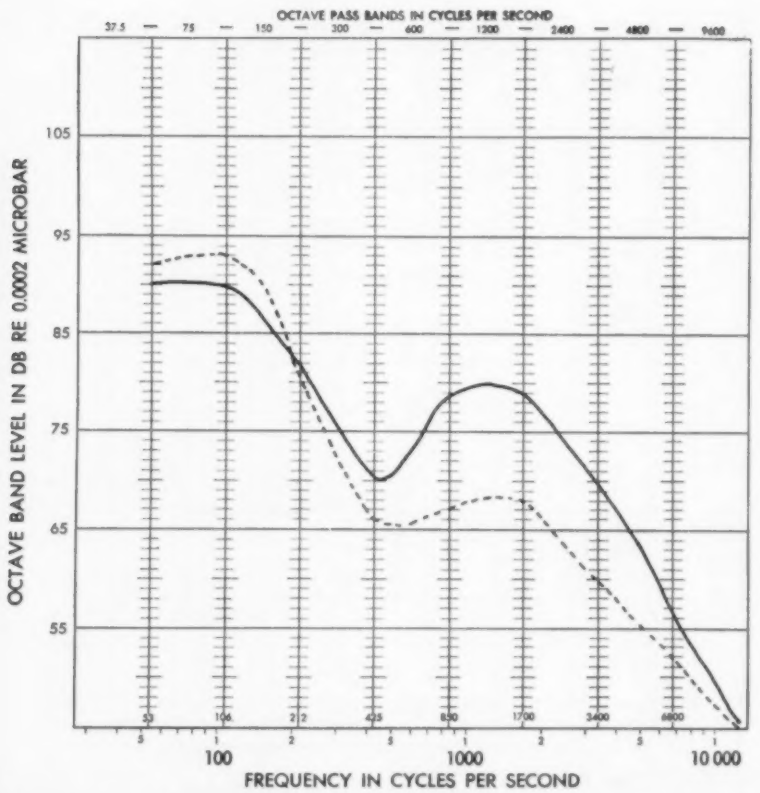


Fig. 7. Typical silenced exhaust noise level 10 ft to side of exhaust outlet for large two-cycle turbocharged gas engine.

Underground Corrosion and Methods of Control

PART 6
(Conclusion)

O. C. Mudd, *Consulting Engineer, Alpine, Texas*

CATHODE AREA SEGREGATION BY INSULATION

Segregation of different sections of a structure, i.e., insulating of a pipeline pump station from the incoming and outgoing line, tanks from connecting lines, large steel reinforced concrete foundations from adjacent buried structures, etc., may be desirable.

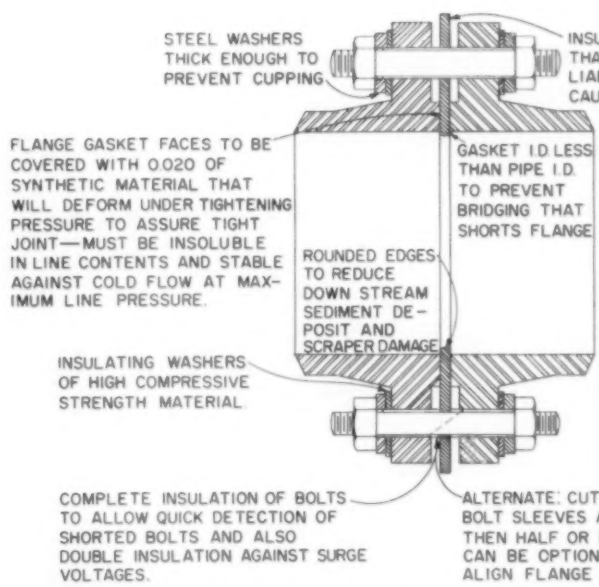
Such segregation offers advantages in current control to the respective cathode areas and in many cases it is good economy through saving in protective unit capacity and unit operating cost.

Insulated flanges installed in piping is one of the most prevalent means of segregation in pipeline systems and around industrial plants.

Well designed and carefully installed segregation measures are occasionally nullified through carelessness or lack of cooperation between construction crafts. Electrical conduit and electrical grounding systems are among the most common sources establishing unwanted paths diverting protective current.

Insulating flanges may become ineffective through bridging across the insulation within, or outside, the pipe by conductive materials. These causes of impairment can be reduced, however, by proper insulation component design.

Insulating gaskets between flange faces that have an inside diameter slightly less than the pipe ID are less susceptible to bridging by conductive material. Recommended are gasket ID of $\frac{1}{8}$ in. less than the pipe ID up to and including 10-in. pipe, 3/16-in. less up to and including 24 in., and $\frac{1}{4}$ in. less for larger sizes. This gasket ID cannot be reduced too much where scrapers pass through the line without danger of insulation damage.


STEEL WASHERS THICK ENOUGH TO PREVENT CUPPING
INSULATION O.D. 1/2" MORE THAN FLANGE O.D. TO REDUCE LIABILITY OF SHORTING AND CAUSING SPARKS.
FLANGE GASKET FACES TO BE COVERED WITH 0.020 OF SYNTHETIC MATERIAL THAT WILL DEFORM UNDER TIGHTENING PRESSURE TO ASSURE TIGHT JOINT—MUST BE INSOLUBLE IN LINE CONTENTS AND STABLE AGAINST COLD FLOW AT MAXIMUM LINE PRESSURE.
GASKET I.D. LESS THAN PIPE I.D. TO PREVENT BRIDGING THAT SHORTS FLANGE
ROUNDED EDGES TO REDUCE DOWN STREAM SEDIMENT DEPOSIT AND SCRAPER DAMAGE
INSULATING WASHERS OF HIGH COMPRESSIVE STRENGTH MATERIAL
COMPLETE INSULATION OF BOLTS TO ALLOW QUICK DETECTION OF SHORTED BOLTS AND ALSO DOUBLE INSULATION AGAINST SURGE VOLTAGES.
ALTERNATE: CUT FULL LENGTH BOLT SLEEVES AT 45° IN CENTER THEN HALF OR FULL INSULATION CAN BE OPTIONAL AND STILL ALIGN FLANGE GASKET.
NOTE: ALL BOLTS AND STEEL WASHERS TO BE FREE OF BURRS AND DEFORMATIONS TO PREVENT INSULATION BREAKAGE.

COMPONENT DIMENSIONS IN TERMS OF FLANGE BOLT DIAMETER "D" OR IN.

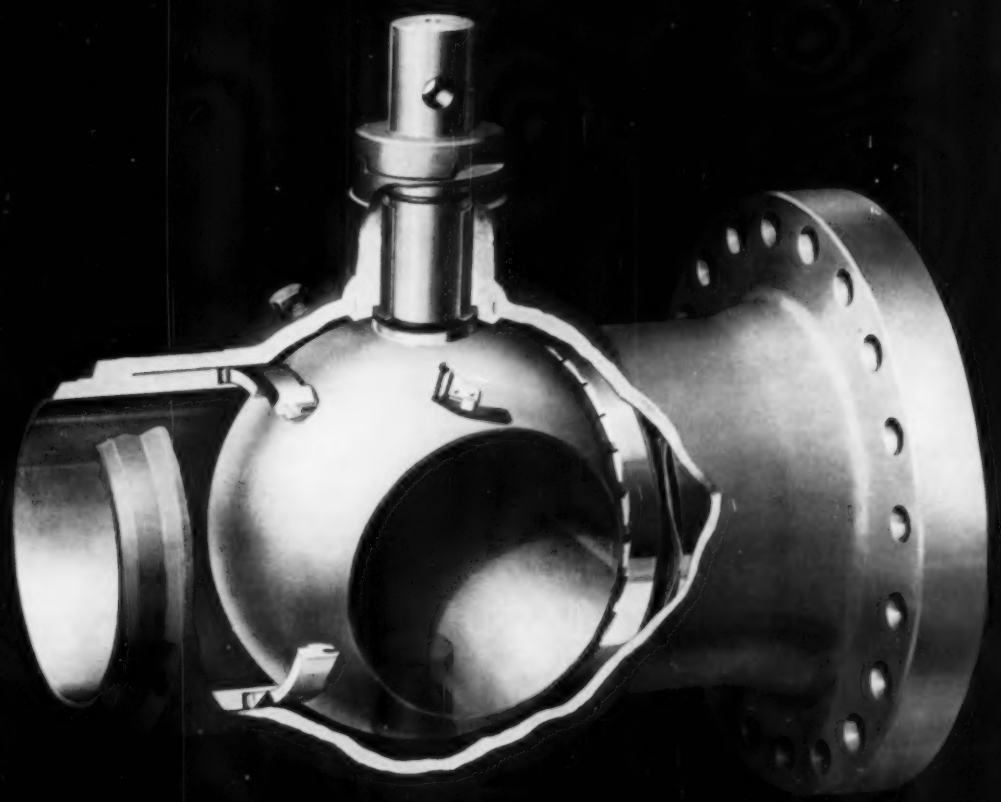
WASHERS					
STEEL			INSULATING		
I.D.	O.D.	TH.	I.D.	O.D.	TH.
D+1/16"	1.34D+3/16"	*	D+1/16"	1 3/4 D+3/16"	1/8"

* 1/8" for 5/8" & 3/4" bolts 3/16" for larger

INSULATING SLEEVES		
I.D.	O.D.	LENGTH
D	D+1/16"	ACCORDING TO FLANGES AND TYPE REQUESTED

GASKET DIMENSIONS			
PIPE SIZE	I.D.	O.D.	TH.
TO 10" INCL.	PIPE I.D. −1/8"	FLNG. O.D. + 1/2"	1/8"
12 TO 24" INCL.	" " −3/16"	" " "	3/16"
ABOVE 24"	" " −1/4"	" " "	1/4"

FIG. 16. Recommended flange insulation component design.



NEW—FOR GENERAL USE

For Pipe Lines—Chemical, Refining and Gas Processing Plants—Oil Well Drilling and Producing

Cameron

BALL VALVE

with the Exclusive Rotating Seats

These valves handle the most abrasive and corrosive fluids—cannot freeze—cannot develop excessive body pressure; provide up-stream seating, double block and bleed, all with unbelievably easy operation.

CAMERON BALL VALVES SEAL ON A NEW SURFACE WITH EACH OPERATION

ROTATING SEAT PRINCIPLE

CAMERON BALL VALVES use an advanced form of the exclusive rotating seat principle* made famous in Cameron's Type "F" Gate Valve. Each operation of the valve partially rotates the seat to change the relation of the mating surfaces and to provide a continuous reseating action.

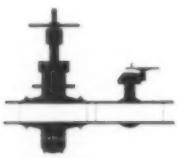
The astounding improvement in service life and tightness brought on by this advancement places the CAMERON BALL VALVE in a completely new dimension of reliability and extended use—permits for the first time "sealed for life" construction.

*Patents Applied For

NEW MANUFACTURING CONCEPT

Cameron has developed a new technique of manufacture, incorporating a new design*, which permits forging, machining and welding in successive steps. This results in a new kind of structure that is totally accurate and the ultimate in simplicity.

*Patents Applied For

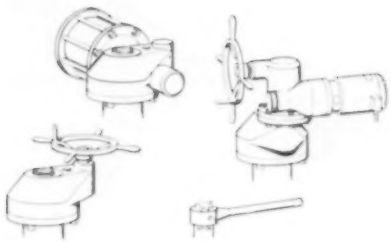


COMPACT DESIGN

This new design concept eliminates bonnets, gaskets and joints and all the problems that arise from them. The weight of these valves is remarkably low and they require only a fraction of the space needed for other valves.

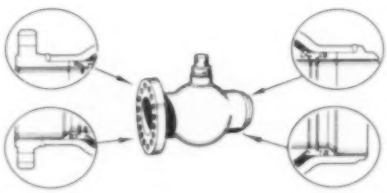
NO MORE LUBRICATION

CAMERON BALL VALVES require no lubrication at any time. Moving surfaces slide on low friction Teflon to seal all joints and provide a life-time of easy operation and bubble-tight service without lubrication.



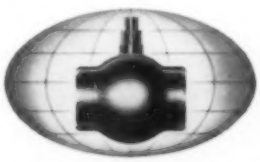
OPERATORS

The CAMERON BALL VALVE requires only a fraction of the effort that other valves must have to operate. Much larger valves may be lever operated with ease. When necessary, highly efficient gear operators requiring a minimum of turns and effort are provided. All types of electrical, pneumatic and hydraulic operators manufactured by Cameron are available and special operation problems are solicited. Operators of other manufacture may be installed on request.



SIZES AND TYPES

CAMERON BALL VALVES are available in regular and full bore sizes from 2" to 36" in W.P. 150 psi to 5000 psi. They may be provided, with any end preparation required. Larger bore sizes are available on special order.



CAMERON BALL VALVES are available and will be manufactured worldwide in five Cameron Plants—France, England, Canada, Mexico and the United States. Processes in each plant follow the same specifications and rigid controls established by the home plant in Houston, Texas.

Cameron

IRON WORKS, INC.

P. O. Box 1212 - Houston, Texas

Export Office: 7912 Empire State Bldg., New York City, In England: Cameron Iron Works Ltd., 76 Grosvenor St., London W. 1, England

Outside extension of the gasket ¼ in. beyond the flange periphery reduces the chance of a conducting material establishing a current path across the flange, and also has the safety feature of minimizing the chance of sparking by accidental contact of metal (tools) across the flanges (Fig. 16).

In some types of service it may be desirable to cover insulating flanges, and any such covering should incorporate features assuring insulation retention and prevent moisture accumulation.

Total insulation of flange bolts has the advantage of easy detection of bolt insulation failure without bolt removal.

Assembly and testing of insulating flanges prior to installation in a line assure better component alignment, reducing the chance of installation damage and flange leakage.

Any material used to isolate structures or sections of a structure above or below ground should be known to resist deterioration in contact with its environment, and have mechanical properties minimizing impairment or failure by cold flow or breakage.

Insulation installed above ground is most desirable and installations below the ground should be made accessible for inspection and maintenance if possible.

STRAY CURRENT MITIGATION BY BONDING

Soil resistance to current flow causes potential gradients along the path, and lower resistance paths allow greater current flow for any given gradient.

As most metals placed underground have resistances only a fraction of extremely low resistivity soil, it is then obvious that any continuous metal path along a potential gradient will provide the better current flow path from higher to lower potential soil environment.

The metal surface where current enters from soil to structure becomes a cathode area and there must be an anode area to complete the cell circuit. In an isolated cathodic protection installation the ground bed is the anode area and all cathode area current is confined to a metallic conductor up to the source of current.

In other cases, where continuous metallic structures lay along gradient paths, the cathode area accumulation of current in the higher potential locations returns to the soil in low potential areas when no further metallic path exists, and this portion of the structure surface becomes the anode, suffering metal loss and eventual destruction.

Any anodic surface causes potential gradients of diminishing magnitude with increase of distance away from the anode. The magnitude of any potential gradient depends on the voltage impressed at the anode surface and the extent of such gradients depends on the soil resistance encountered by the current flowing.

It is evident that low impressed voltages and small current flow causes gradients of lesser slope and extent than those from higher voltage and larger currents when the soil resistance is equivalent.

These gradients away from anodes can be termed "electrical mountains" (Fig. 17) down which current flows along the least resistant paths.

Protective units installed near each other and connected to isolated structures frequently cause complications in the control of current to avoid damage. Increasing the number of such installations multiplies the probable paths requiring control.

The solution of such stray current control is through establishing metallic paths between structures to divert anodic area current caused by any installation's potential

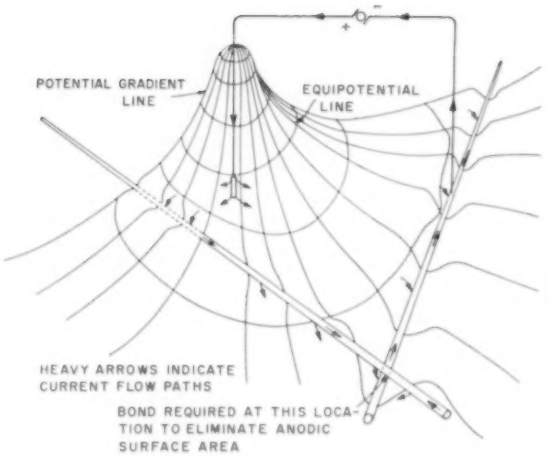

POTENTIAL GRADIENT LINE
EQUIPOTENTIAL LINE
HEAVY ARROWS INDICATE CURRENT FLOW PATHS
BOND REQUIRED AT THIS LOCATION TO ELIMINATE ANODIC SURFACE AREA

FIG. 17. Illustrating soil current flow potential gradient "mountain."

gradients. Establishing such metallic paths is termed "Bonding." Most bonds restrict current flow between structures to that amount necessary in eliminating the stray current anodic areas.

When two or more protective units are in proximity to each other serving to protect two or more independently owned structures, there may be economy and better control of stray current through the installation of common service units to protect these structures.

Recommended procedures in bonding and for joint operated units have been agreed upon by 14 national organizations, or companies, having an interest in fair methods in obtaining equitable results. Those involved in the problems of installing bonds, or joint operated units, should solicit these published recommendations. Among those having the published recommendations are: API, A.G.A., and NACE.

RECORDS

It is essential to establish adequate records of all phases associated with corrosion detection and its mitigation. This is particularly important in the case of buried structures or those where access is difficult or infrequent.

The occasions have been many where information relative to some underground location has been solicited from memory, which has become vague with time, or those who might remember are not available. When a vague memory is the source of information in locating a small underground objective it is obvious that the cost of adequate records over a period of time can be much less than that of extensive proximity excavations necessary in search of one such objective.

Casual observations, appearing to be irrevelant at the time recorded, have given valuable information at a later date, and correlated information compiled over periods of time have revealed unsuspected causes of structure impairment that resulted in maintenance modifications to obtain better results at less cost.

Recording of corrosion leaks establishes a pattern allowing some degree of forecasting further occurrences as long as the environment causing these leaks does not change. Such records assist in appraising the most economical methods of mitigation.

The exact location of buried cables, their connections and anodes associated with protective installations, recorded on

sketches or drawings prove their worth when repairs or replacements are needed.

Protective installation performance is assured only by periodic observations of the unit and the potentials maintained along the cathode section, and the recording of these observations shows any deviations that originate from changing conditions. These recorded observations have occasionally revealed accidental contact with other structures, which nullified part of the established extent of protection, and also have revealed coating damage on well-coated lines.

Such data recorded in a manner to allow comparison will show seasonal trends, or other trends existing over time, and their proper interpretation assists in effecting improvements to existing and future installations.

Record forms and drawings should be kept to a minimum consistent with the retention of essential information and requiring the least time possible in their preparation and entry of data.

ECONOMICS

Prevention or mitigation of corrosion is justified only when the cost results in actual or potential savings in maintenance expense and/or increase of revenue exceeding that of the mitigation measures applied.

When maintenance expense is accounted for on existing structures, particularly when expense attributed to corrosion has been segregated, and the trend of corrosion damage has been established by these records, it then is possible to estimate the amount justified for corrosion control. Tests with temporary portable units can determine whether the proposed protective measures can be within the justified amount or what portion of the structure can be protected profitably.

Protection of new structures must be predicated on past experience with corrosion on existing nearby structures; however, such comparisons may lead to erroneous conclusions. A new line laid through terrain where corrosion was of no consequence was subjected to severe corrosion later by subsequent soil contamination.

In the light of present day materials, equipment, and trends, it is considered an unwise risk to place any extensive structure underground without effective coating supplemented with cathodic protection.

Corrosion control of new underground structures, particularly pipelines, has these favorable aspects:

1. No additional metal is needed to allow for corrosion.
2. Reduces transported commodity loss.
3. Reduces property damage and damage claims.
4. Reduces maintenance expense.
5. Reduces shut downs caused by corrosion with possible loss of revenue.
6. Reduces fire hazard to company personnel and public where commodity is highly flammable.
7. Conserves structure metal.

Reduction of metal weight in present day thin-wall pipe compared with earlier heavier wall pipe effects a saving in metal purchase nearly equivalent to the cost of a good coating applied to the pipe, and an additional saving in the transportation cost from mill to the job.

In some instances where records were kept they revealed that commodity losses were small even on old lines to which protection had been applied, and virtually non-existent on protected new structures.

The trend in property damage claims resulting from corrosion leaks and associated repair work reflects an ever-continuing increase, hence any reduction in such damages increases savings as time passes. Also, damages often have adverse effects on public good will.

Reduction in structure corrosion curtails expense of repairs and this becomes a more important item with large diameter, prestressed steel pipe, as the items of excavation, manner of effecting repairs, and probable loss of revenue by line shut down during repairs, will be proportionately much greater in cost than for smaller diameter lines.

Most of our recent constructed oil pipelines and modified older lines operate with closed systems that allow transportation of high volatility products added into the normal oil stream. The prevalence of this practice increases fire hazards when line leaks occur, hence any reduction or prevention of such leaks reduce this hazard.

The trend of increasing metal cost and diminishing natural resources contributes to the ever-present need of conservation, therefore, effectively protected structures removed after termination of their economic life in their existing location may have salvage values equal to an appreciable part of the original cost.

SUMMARY

Underground corrosion and most other forms of metal corrosion at normal temperatures are the result of electrochemical action, which establishes the component parts of electrochemical cells during activity.

The energy necessary to sustain galvanic cell action is derived from the available heat of formation, which differs with each metal, and those requiring greater heats of formation are predominately more susceptible to corrosion.

Active components of corrosion cells can be determined by measurement with suitable electrical instruments and accessories. The rate of action, or some approximation of the rate, also can be determined by suitable measurements.

Counter voltages applied to a corroding, or anodic, electrode surface, exceeding that of the electrode oxidation reaction, will stop or prevent corroding action by establishing a cathode surface. Cathodic protection is the application of this principle for practical use.

Coating cathode surfaces with high resistance materials restricts current flow in electrochemical cells and this restriction increases in proportion to the coating resistance.

The economic value of cathodic protection applied to existing bare and poorly coated lines has been demonstrated by cost records. The combination of good coatings supplemented with cathodic protection has demonstrated that underground structures can be maintained free of corrosion damage, and also that stray current damage to or from other structures can be minimized.

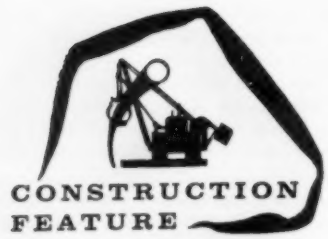
Structure segmentation by insulation can benefit in controlling protective current paths, which often reduce current requirements, thus reducing cost of protection.

Proper bonding between structures to eliminate stray current damage is good economy as well as an obligation in maintaining equity.

Adequate records are esential in establishing corrosion trends and also in the continuance of effective mitigation measures.

The economics of protective measures for old existing lines can be determined only by tests and calculations, but there are few, if any, conditions that justify omission of complete protection from new underground structures.

★ ★ ★



Pipeline Projects

Argentina Asks Bids On Big Gas Pipeline

Argentina has issued an international call for tenders for a multi-million-dollar natural gas transmission line from Comodoro Rivadavia in Patagonia to the Greater Buenos Aires area.

Cost of the 1000-mile, 30-in. pipeline is estimated by oil industry sources at about $300,000,000.

A major feature of the job from the financing and general economic policy standpoint, according to the announcement, is that the pipeline will be operated by the builder for an indefinite period with a toll payment for each cubic meter of gas transmitted.

Specifications call for an initial throughput of 353,140,000 cu ft and 200,000 hp in compressor installations, with plans to increase throughput to 529,710,000 cu ft in a later stage.

Bids are to be submitted by November 4.

To Extend Delta Line

The first extension of Shell Pipe Line Corporation's 120-mile Delta pipeline, which went into operation in March, 1959, has been announced.

Plans to extend the line that links crude oil production facilities at the mouth of the Mississippi River and extends to Norco, Louisiana, include addition of five pumping installations, laying of 11.5 miles of pipe and purchase of another 1.5 miles of existing pipeline down the Southwest Pass of the Mississippi River. The new pipeline will transport from West Delta Block 83 and Burrwood fields to central facilities at Southwest Pass about 10,000 bbl of crude oil a day presently being barged.

Some four miles of 8-in. pipe will be laid along the east bank of Southwest Pass, connecting with an existing 8-in. line that leads to the central terminal. The line then will fork off into two lines — one a 6-in. continuing 3.2 miles along the east bank to a mile south of Burrwood; and the other an 8-in. line crossing Southwest Pass and connecting to 3.6 miles of 6-in. pipe laid along the west bank of Southwest Pass.

Four of the pumping installations will be equipped with 75-hp gas engines, and the fifth will have a 30-hp motor. All installations will be mounted on concrete platforms.

Construction is expected to be completed by late September.

FPC Ok's 58 Miles Of Gas Line

Equitable Gas Company's proposal to construct and operate approximately 31 miles of 16-in. and 27 miles of 20-in. pipeline in West Virginia and Pennsylvania has received Federal Power Commission authorization. The facilities will increase the company's overall system capacity by 76,000,000 cu ft daily.

Seeks To Develop Gas Storage In Kentucky

The development of Kentucky's West Greenville gas field as a natural gas storage reservoir has been proposed by Texas Gas Transmission Corporation in an application filed with the Federal Power Commission.

Texas Gas proposes to construct approximately 29 miles of 12-in. pipeline from the field in Muhlenberg to main line facilities near Slaughters, a 1760-hp compressor station, a dehydration plant, and a meter station, at a cost of about $2,506,000.

The purchase of rights and interest to the field from Western Kentucky Gas Company would bring the total cost to $3,561,527.

Texas Gas plans to develop the storage pool later to an estimated peak-day deliverability of 85,000,000 cu ft.

Upon development of 21,500,000 cu ft of peak-day withdrawal capacity, Texas Gas proposes to abandon, by sale to Western Kentucky, all rights and interests in the Hickory School and Grandview storage fields which have a combined peak-day withdrawal capacity of 21,500,000 cu ft.

Utah Construction Planned

Construction of about 33 miles of 20 and 24-in. gas pipeline is planned this summer and fall by Mountain Fuel Supply Company on its Utah system.

The job will consist of 6.7 miles of 24-in. from Montain Dell to Sunnyside station, 6.4 miles of 20-in. from Kanda Junction to Green River station, and 20 miles of 20-in. from Piedmont to Yellow Creek.

TET Plans New Loops, Compression Facilities

Plans for a $17,500,000 expansion program that will increase Texas Eastern Transmission Corporation's daily delivery capacity by 50,000,000 cu ft has been revealed in an application filed with the Federal Power Commission.

New facilities required to make the increased deliveries include approximately 66 miles of 30-in. loops to be added to the company's system between Vidor, Texas, and Lambertville, New Jersey; the addition of 33,710 hp in compression equipment at four existing gas compressor stations; and necessary metering and regulating facilities.

The company hopes that authorization will be granted soon enough to permit completion for the 1960-61 heating season. "The majority of the gas will go to 15 present customers for whom Texas Eastern is the sole supplier of natural gas," according to Orville S. Carpenter, president of the company.

Two LPG Lines Planned

Applications have been filed for permission to construct two LPG pipelines in Alberta to carry excess liquid products from gas processing plants to refineries, all under British-American Oil Company, Ltd., operation. The company's wholly-owned pipeline operating subsidiary, Britamoil Pipe Line Company, Ltd., filed the applications — one for a 125-mile, 6-in. line from the Pincher Creek gas field to B.A.'s refinery in Calgary; and the other for a 60-mile, 8-in. line from the Homeglen-Rimbey field to the B.A. refinery in Edmonton.

The Alberta Oil and Gas Conservation Board is expected to set a hearing for later in the summer.

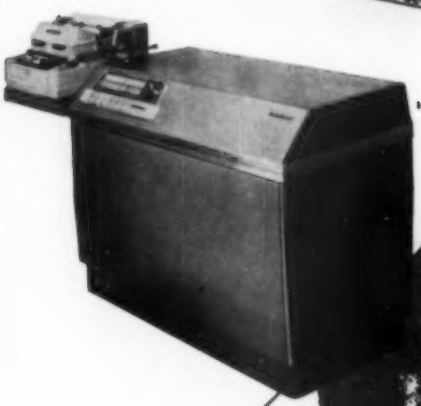
NNGC Seeks Expansion In Texas

To accommodate volumes of gas taken from the North Hansford and Lips producing areas in Hansford, Ochiltree, and Roberts counties, Texas, Northern Natural Gas Company is seeking permission from the Federal Power Commission to build a 7000-hp compressor station; about 40 miles of varying diameter gathering lines; an additional 50,000,000 cu ft per day in dehydration capacity; and an additional 100,000,000 cu ft per day in hydrocarbon extraction capacity at its Spearman plant.

The proposed gathering lines would loop or replace existing lines.

Cost of the proposed facilities would be approximately $5,311,135.

THE BIG DIFFERENCE IN AIR COOLED EXCHANGERS . . .



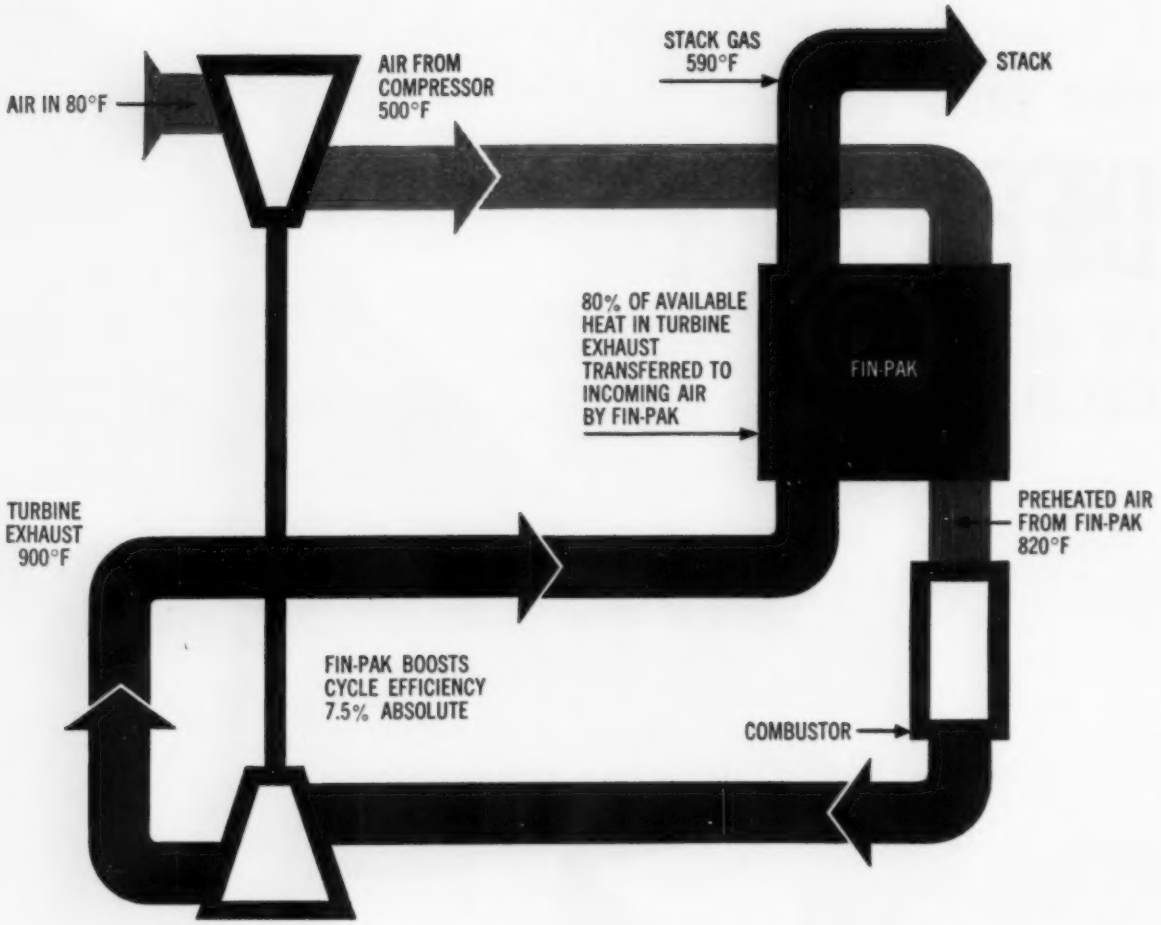
. . . uncompromising quality, through 22 years of supplying air cooled equipment to the industry. Today, as always, Happy is continually striving to improve its product through research, latest shop equipment, time, motion, method and design studies . . . all calculated to bring you the finest equipment available at the most economical level.

Now a new dimension has been added. A Royal McBee LGP-30 Electronic Computer has been installed in our Engineering Department to perform our rating calculations previously done by hand. Now, within minutes we are able to vary tube lengths, pass arrangements, number of tubes, rows of tubes, face velocities, etc., — all of the normal variables — to find the optimum unit for your requirements.

HAPPY

THE HAPPY COMPANY — BOX 770 — TULSA, OKLAHOMA

EXPERIENCE COMPARES — THE DIFFERENCE


AIR IN 80°F
AIR FROM COMPRESSOR 500°F
STACK GAS 590°F
STACK
80% OF AVAILABLE HEAT IN TURBINE EXHAUST TRANSFERRED TO INCOMING AIR BY FIN-PAK
FIN-PAK
PREHEATED AIR FROM FIN-PAK 820°F
TURBINE EXHAUST 900°F
FIN-PAK BOOSTS CYCLE EFFICIENCY 7.5% ABSOLUTE
COMBUSTOR

IF YOU FIND A GAS TURBINE MOST ECONOMICAL FOR PIPELINE COMPRESSORS, YOU SHOULD ALSO CONSIDER A FIN-PAK® BECAUSE:

- *Fin-Pak can cut fuel consumption 30%*
- *Fin-Pak can be installed in less than 500 manhours*
- *Fin-Pak needs little or no maintenance*

If your surveys show that a gas turbine is the most economical power source for pipeline compressor stations, the advantages of a Fin-Pak heat regenerator will make a gas turbine look better than ever. For example:

1. The heat you recover from turbine exhaust with a Fin-Pak can make your turbine run on 30% less fuel*. (The flow diagram at the top of the page shows you how it works.)

2. You can install a Fin-Pak *completely* on a large (5000 to 8000 HP) gas turbine in less than 500 manhours, thanks to Fin-Pak's prefabricated construction, compact size and light weight.

3. Fin-Paks on the pipeline compressor stations have required no cleaning to maintain the performance for which they were designed.

Some Fin-Paks have been in operation for over five years without a maintenance problem. We will be glad to tell you more about the Fin-Pak, and how it can cut your turbine operating costs. Simply call or write The Air Preheater Corporation.

*An 80% effective Fin-Pak in a gas turbine cycle at 6 to 1 pressure ratio and a turbine inlet temperature of 1500°F. can cut fuel consumption by more than 30%.

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.
Phone: MUrray Hill 2-8250

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Teletype machines help cut costly paperwork

A Teletype machine equipped with a simple sprocket-feed mechanism can handle multi-carbon forms as readily as the more familiar plain paper on which messages are transmitted. Thus distances can be bridged not only with information, but with information that is preprocessed, ready to go to work.

Example: A sales order is transmitted from branch office to home office and reproduced accurately and precisely on a form in the Teletype machine—with carbons for production, accounting, shipping, etc. No further order-writing effort needed, no recopying errors.

Teletype printers handle a wide variety of multi-copy forms. Moreover, the usefulness of this technique can be further extended with Teletype tape punching and reading equipment—which can capture, store and utilize repetitive data to further mechanize paperwork procedures.

Teletype Corporation manufactures this equipment for the Bell System and others who require the finest in data communications equipment.

Typing Tape Punch

Tape Reader

Send-Receive Page Printer

Automatic Send-Receive Set

FREE Model 28 line folder. Write Dept. 92H, 5555 Touhy Avenue, Skokie, Illinois.

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SUBSIDIARY OF *Western Electric Company* INC.

See Teletype Corporation's equipment exhibit at the Western Electronic Show and Convention, August 23-26, Los Angeles, Calif.

for "deep well"
installation, specify

Duriron®
impressed current
Anodes

Durco high silicon iron alloys (Duriron, Durichlor, and D-51) are being used almost exclusively for new deep well anode installations.

Durco anodes combine the advantages of:

1 PERMANENCY *(Weight loss 1/20 of that of steel)*

2 EASE OF INSTALLATION *(Bulk volume of scrap steel is avoided)*

3 MINIMUM TOTAL COST *(No backfill or pre-packing of anodes required)*

Durco high silicon iron alloys are resistant to sea, brackish, and fresh waters, as well as all soil environments. Complete details are contained in Bulletin DA/6.

THE DURIRON COMPANY, INC.
DAYTON, OHIO

DURCO

WITH THE PIPELINE CONTRACTORS

● **Banister Construction Company, Ltd., 625 Northern Hardware Building, Edmonton, Alberta, Canada.** Is laying an indeterminate amount of 3, 4, and 6-in. crude oil gathering system for *Producers Pipelines, Ltd.*, in the Estevan, Saskatchewan, area. Basil Seemann is field superintendent, and foremen are Steve Slade, D. Gooderick, and Joe Schmidt. Has contract to construct for *Saskatchewan Power Corporation* approximately 25 miles of 4-in. pipeline from Canora to Kamsack and 35 miles of 4-in. from Tisdale to Nipawin with a 20-mile, 4-in. lateral to Carrot River.

● **Bechtel Corporation, 220 Bush Street, San Francisco 4, California.** Has been awarded contract by *Midwestern Gas Transmission Company* to construct a 115-mile section of pipeline from the Canadian border to the Becker County-Clay County line in Minnesota.

● **Bristow-Hyde Engineering Corporation, First City National Bank Building, Houston, Texas.** Has been awarded a contract by *Midwestern Gas Transmission Company* to construct 39 miles of laterals in connection with the company's 504-mile, 24-in. pipeline from the Canadian border.

● **Brodie Construction Company, Box 2646, Amarillo, Texas.** Has been awarded contract to construct for *Aztec Pipe Line Co.* a 36-mile jet fuel pipeline from Artesia, New Mexico, to Walker Air Force Base near Roswell, New Mexico.

● **O. R. Burden Construction Corporation, P. O. Box 5216, Tulsa, Oklahoma.** Has been awarded a joint contract with H. B. Zachry Company to construct *Old Ocean Fuel Company's* 370-mile natural gas pipeline between the Gulf Coast area, south of Houston, Texas, to the Fort Worth area. Spread No. 1, consisting of 92 miles, begins at Washington County and ends at Limestone County, under the supervision of F. W. Lewis. Spread No. 2, consisting of 92 miles, begins at Limestone County and ends at Fort Worth, under the supervision of C. M. Hoffman. Has been awarded contract by *Natural Gas Pipeline Company* to construct 58 miles of 36-in. pipeline in the vicinity of Concordia and Ford, Kansas. R. M. Jones is supervising, and field office is at Glasco, Kansas.

● **Collins Construction Company, P. O. Box 86, Port Lavaca, Texas.** Has in progress the construction of dual 12 and 24-in. natural gas pipeline river crossings for *Petroleos Mexicanos* between Pemex City and Mexico City in Mexico. Tom Broom is supervising. Is laying 23,000 ft of 6 and 8-in. pipeline for *British-American Oil Producing Company* from Johnson's Bayou, Louisiana, to offshore Block 20, under the supervision of Pat Patterson. Is constructing for British Petroleum Company, Ltd., and Iraq Petroleum Company, Ltd., 20 miles of dual 32-in. from Fao, Iraq, to an artificial offshore island in the Persian Gulf. Harry Frankman is project manager of the latter.

● **Contracting and Material Company, 1235 Dodge Avenue, Evanston, Illinois.** Has received a contract to construct for *Northern Illinois Gas Company* a 73-mile, 30-in. natural gas pipeline between Troy Grove and Aurora, Illinois. Field office will be at Earlville. Arthur J. Fry has been appointed superintendent. Has been awarded contract by *Midwestern Gas Transmission Company* to build 54 miles of pipeline from Wanderoos, Wisconsin, to the Chippewa River.

● **D. Michael Curran & Company, Eklund Building, Great Falls, Montana.** Has been awarded a joint contract with C. E. Wilson Construction Company to construct an 8-in. products pipeline in Montana and North Dakota for *Cenex Pipeline Company*, a subsidiary of Farmers Union Central Exchange, Inc.

● **Fulghum Contracting Corporation, Box 1181, Harrisburg, Pennsylvania.** Has been awarded contract by *Transcontinental Gas Pipe Line Corporation* to lay about 18 miles of 20-in. pipeline in Delaware County, Pennsylvania, and Gloucester County, New Jersey.

● **R. H. Fulton & Company, Box 1526, Lubbock, Texas.** Has received contract from *Yellowstone Pipe Line Company* to construct an 85-mile petroleum products pipeline from Helena to Great Falls, Montana.

● **Grayco Constructors, Inc., Box 4147, Austin, Texas.** Has been awarded contract by *Midwestern Gas Transmission Company* to lay 54 miles of pipeline from the Becker County-Clay County line in Minnesota to near New York Mills, Minnesota.

● **Groninger & King, Inc., Box 1381, Pampa, Texas.** Has received a contract from *Northern Natural Gas Company* to construct 15 miles of 4 through 6-in. gathering lines in the Ashland, Kansas, area, with headquarters at Ashland and W. G. Puckett supervising. Is taking up 4, 6, and 8-in. gathering lines in the Lakin, Kansas, area for *Kansas-Nebraska Natural Gas Company* and laying 28 miles of 8, 20, 26, and 30-in., with A. L. Sikes supervising at Lakin. Is laying about 26 miles of 4, 6, 8, and 10-in. gathering lines for *El Paso Natural Gas Company* in the area of Beaver, Oklahoma, where Frank Kelp is supervising.

● **Hall Construction Company, 1105 N. Carlton, Liberal, Kansas.** Is working on a 330-mile, 4 through 12-in. gathering system in western Kansas for *Panhandle Eastern Pipe Line Company*. Supervising are Mike Bell and M. E. Banning.

● **Harbert Construction Corporation, Box 1369, Birmingham, Alabama.** Has received a contract from *Michigan-Wisconsin Pipeline Company* to lay 85 miles of 16-in. pipeline from Weyauwega to Marinette, Wisconsin, and about 17 miles of 4-in. lateral lines, under the supervision of T. E. Walker.

● **Houston Contracting Company, 2807 Buffalo Speedway, Houston 6, Texas.** Has been awarded a contract by *Michigan-Wisconsin Pipe Line Company* to build 92 miles of 24-in. pipeline from Appleton to Marshfield, Wisconsin. Headquarters will be at New London, under the supervision of R. L. Silar. Has been awarded a contract by *Shell Pipe Line Corporation* to reroute 9 miles of 10 and 22-in. pipeline across the proposed Oologah Reservoir in Rogers County, Oklahoma. A. J. Slovack will supervise, and Nowata will be the site of the field office. Has been awarded a contract by *Midwestern Gas Transmission Company* to construct two new compressor stations and 21 meter stations in Minnesota, North Dakota, and Wisconsin. S. C. Downing will supervise at Noyes, Minnesota, and J. J. Nolan at Staples, Minnesota. Has received a contract from the same company to construct 109 miles of pipeline from the Mississippi River to Wanderoos, Wisconsin.

● **Lasley Construction Corporation, Box 1465, Hobbs, New Mexico.** Is constructing for *Phillips Petroleum Company* an 85-mile, 2 to 16-in. gathering line in Eddy County, New Mexico.

● **M & R Pipeliners, Inc., Elizabeth, Pennsylvania.** Has been awarded a contract by *Hope Natural Gas Company* to build 19 miles of 20-in. pipeline in West Virginia. It consists of 9 miles between the Kennedy Station and Dry Fork and 10 miles from Ellenboro to Schultz.

● **Majestic Contractors, Ltd., 49 Jackes Avenue, Toronto 7, Ontario, Canada.** Has in progress 14 miles of 6-in. and 18 miles of 6 through 8-in. crude oil pipeline in the Swan Hills area, Alberta Province, for *Federated Pipe Lines, Ltd.* Superintendents are K. B. Killingsworth and Jeff Minter. Has received a contract from the same company to build about 41 miles of crude oil pipeline from Oliver to Highbridge, Alberta, with Jeff Minter supervising at Morinville; has been awarded a contract by *Michigan-Wisconsin Pipe Line Company* to lay approximately 60 miles of 30-in. pipeline near Joliet, Illinois, where headquarters will be located under the supervision of R. L. Leonard. Is doing relocation work at the cloverleaf of Highway 10 in Toronto for *Trans-Northern Pipe Line Company*, with George Oswald supervising at Cooksville headquarters. Is laying 12 miles of 8-in. pipe on the Woodstock-Norwich line in Ontario for *Union Gas Company of Canada, Ltd.*, with Don Elliott supervising at Norwich. Has been awarded contract for construction of 50.7 miles of 30-in. line for *Trans-Canada Pipe Lines, Ltd.*, between its Ile des Chenes compressor station and Emerson, Manitoba, with C. A. (Cal) Callahan directing and K. B. (Rusty) Killingsworth acting as spread superintendent.

● **Mannix Company, Ltd., 737 - 8th Avenue, S. W., Calgary, Alberta, Canada.** Is constructing 94,000 ft of 30-in. pipeline for *British Columbia Electric Company, Ltd.*, between Huntingdon and Livingston Road and 46,000 ft of 20-in. in the Burrard Inlet area. V. J. Worcester is superintendent and field office is at Abbotsford. Is constructing the Kenora, Ontario, compressor station with building extension at Port Arthur for *Northern Ontario Pipe Line Crown Corporation*. J. Hobbs is superintendent.

● **J. Ray McDermott & Company, Inc., Box 38, Harvey, Louisiana.** Has received a contract from *Columbia Gulf Transmission Company* to build a dual 24-in. crossing of the Mississippi River near Mayersville, Mississippi.

● **Missouri Valley Dredging Company, Box 1592, Burlington Station, Omaha 8, Nebraska.** Has been awarded a contract by Panama Williams Corporation to install the Maumee River crossing near Toledo, Ohio, on the *Buckeye Pipe Line Company* project. Field office is at Toledo, and superintendent is Harold Hubbard. Has received contract to lay a crossing of the Chippewa River for *Midwestern Gas Transmission Company*.

● **Montin-Harbert Pipe Line Construction Company, Inc., 2808 First National Building, Oklahoma City, Oklahoma.** Has received a joint contract with Sadler Bros. Pipeline Construction Company to build an 8 and 12-in. natural gas pipeline system in central Oklahoma for *Mustang Fuel Corporation*.

● **Panama, Inc., 1801 Tennessee Building, Houston 2, Texas.** Has received contract to construct for *Midwestern Gas Transmission Company* 66 miles of pipeline from the Chippewa River to Marshfield, Wisconsin.

● **Panama Williams Corporation, 1418 Melrose Building, Houston, Texas.** Has been awarded a contract by *Michigan-Wisconsin Pipeline Company* to lay approximately 115 miles of 4, 6, and 8-in. pipeline in loops in the vicinity of Stevens Point, Wisconsin. Field office is located at Antigo, Wisconsin. Superintendents are Emmett Sutton and Ned McElmurray. Has been awarded a contract to build 14 miles of 22-in. pipeline between Samaria, Michigan, and Toledo, Ohio, and a crossing of the Maumee River near Toledo for *Buckeye Pipe Line Company*, has appointed W. H. Shiflett and Emmett Sutton superintendents, and located field office near Monroe, Michigan. Has been awarded a contract by *Northern Natural Gas Company* for work beginning in the northern part of Iowa and extending in loops to the northwest part of Oklahoma, passing through Nebraska and Kansas. W. H. Shiflett is superintendent.

● **Pentzien, Inc., 1504 Dodge Street, Omaha, Nebraska.** Has been awarded a contract by *Texas Eastern Transmission Corporation* to install a single 20-in. Arkansas River crossing near Little Rock, where field office will be located under the supervision of James E. Garner. Has received a contract from *Arkansas Industrial Pipe Line Corporation* to install a dual 18-in. Arkansas River crossing near Wright, Arkansas. Superintendent is T. D. Stout; field office is at Pine Bluff, Arkansas. Has been awarded contract by *Natural Gas Pipeline Company of America* to construct a dual 30-in. Illinois River crossing near Plattsmouth, Nebraska, with headquarters at Omaha and James R. Zeman supervising. Has received a contract from *Midwestern Gas Transmission Company* for a dual 24-in. crossing of the St. Croix River near St. Croix Falls, Wisconsin, where headquarters is located under the supervision of T. D. Stout.

● **Pipe Line Technologists, Inc., 3431 Alabama, Houston, Texas.** Has a contract to construct for *Seadrift Pipeline Corporation* a 108-mile products line from Union Carbide Corporation's Seadrift, Texas, plant to Humble Oil & Refining Company's King Ranch plant at Ella, Texas.

● **Popich Marine Constructors, Inc., Box 26343, New Orleans, Louisiana.** Has received a contract from *Midwestern Gas Transmission Company* to construct a crossing of the Mississippi River.

● **H. C. Price Company, Price Tower, Bartlesville, Oklahoma.** Is double jointing 154 miles of 24-in. pipeline for *Midwestern Gas Transmission Company* in Minnesota, with Don Barcus as foreman; and has received a contract from the same company to construct 56 miles of pipeline from New York Mills, Minnesota, to the Mississippi River. Has been awarded a contract by *Texas Eastern Transmission Corporation* for the following work in Pennsylvania: 23 miles of 20-in. with Elwood Roth as superintendent; about 42 miles of 24-in. with C. E. Shivel as superintendent and Lewiston as headquarters; and 39.5 miles of 24-in. with C. R. Ice as superintendent and Renovo as headquarters. Has received contract from *Peoples Gulf Coast Natural Gas Pipe Line Company* to lay about 83 miles of 30-in. pipeline in Missouri and Illinois, with W. L. Olrich as superintendent and Murphysboro, Illinois, as headquarters.

● **Rosson-Richards Processing Company, Box 35037, Houston 35, Texas.** Has been awarded contracts by *Midwestern Gas Transmission Company* to fabricate approximately 3000 concrete river weights along the company's right-of-way from the Mississippi River eastward to Marshfield, Wisconsin. Superintendent is T. L. McPherson.

● **Sadler Bros. Pipeline Construction Company, 617 Cravens Building, Oklahoma City, Oklahoma.** Has received a joint contract with Montin-Harbert Pipe Line Construction Company, Inc., to build an 8 and 12-in. natural gas pipeline system in central Oklahoma for *Mustang Fuel Corporation*.

● **Shamrock Constructors, Inc., Box 1177, Lansing, Michigan.** Has been awarded a contract by *Great Lakes Pipe Line Company* to construct a 60-mile, 8-in. pipeline between Grinnell and Waterloo, Iowa.

● **Sharman, Allen, Gay & Taylor, Inc., Box 13152, Houston, Texas.** Has been awarded a contract by Delta Engineering Company to construct a dual 12-in., 10-mile crossing of Turnagain Arm for *Alaska Pipe Line Company*, with Chester Lake as superintendent and Anchorage as headquarters. Has received contract from *Columbia Gulf Transmission Company* to lay about 4 miles of 24 and 30-in. pipeline in connection with a dual 24-in. Mississippi River crossing near Lake Providence, Louisiana, where R. N. Cain will supervise. Has been awarded a contract by *Kenai Pipe Line Company* to lay approximately 20 miles of 8-in. pipe from Mikiski Terminal to Swanson River Unit located 9 miles north of Kenai, Alaska, where headquarters is located. T. L. Beard is superintendent. Has received contract from *Texas Eastern*

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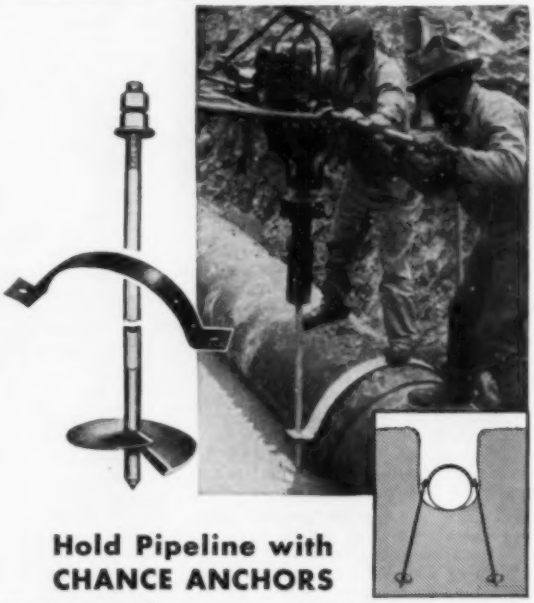

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Transmission Corporation to lay about 20 miles of 30-in. near St. Francisville, Louisiana, and about 18 miles of 30-in. near Clinton, Mississippi. Field office will be located at St. Francisville, and E. D. Singleton will be superintendent.

● **Somerville Construction Company, 6648 Fulton Road, Ada, Michigan.** Has been awarded a contract by *Buckeye Pipe Line Company* to build 27 miles of 16-in. pipeline between Samaria and Trenton, Michigan. Harold Cook has been named superintendent.

● **Stanley-Bledsoe Corporation, 612 Daniel Building, Tulsa 3, Oklahoma.** Has been awarded a contract by *Trunkline Gas Company* to double joint 78 miles of 30-in. pipe in Mississippi, Tennessee, and Louisiana. Has been awarded a contract to internally clean and coat 150 miles of pipe for *Midwestern Gas Transmission Company's* 24-in. pipeline from Emerson, Manitoba, to Marshfield, Wisconsin. Headquarters for the work is Gadsden, Alabama.

● **Stelco, Inc., 905 Barton Springs Road, Austin, Texas.** Has been awarded a contract by *El Paso Natural Gas Company* to lay an undetermined amount of various size lines in the Shamrock field under the supervision of Al Blanchard and W. K. Hancock.

● **Turriff-Burden, Ltd., (subs. Burden International, Ltd., Box 5216, Tulsa, Oklahoma).** Has been awarded a contract by the *Iraq Petroleum Company, Ltd.*, for the construction of 315 miles of 30 and 32-in. pipeline from Kirkuk to the Syrian border and connecting Rumaila and Fao. The project office in London, England, will be managed by W. T. Barker. Field construction superintendent is John H. Miller; assistant superintendent is Arnold Smith; and manager of the field office in Baiji, Iraq, is G. E. Suagee.

● **Vaughn & Taylor Construction Company, Inc., Box 3266, Odessa, Texas.** Is constructing in the vicinity of Artesia, New Mexico, 25 miles of 2 through 22-in. pipeline for *Pan American Petroleum Corporation*, with H. M. Sparks supervising; and 20 miles of 2 through 10-in. for *Humble Oil & Refining Company* with C. H. Stradley supervising.

● **Western Pipe Line, Inc., Box 1076, Austin, Texas.** Has been awarded contracts by *Texas Eastern Transmission Corporation* to construct approximately 35 miles of 30-in. in three loops in Pennsylvania, with headquarters at Jonestown and W. E. Wells supervising; and 44 miles of 30-in. loop lines in West Virginia and Pennsylvania, with headquarters at Moundsville, West Virginia, and John R. Wells supervising.

● **Williams Brothers Company, National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has been awarded a contract by the *National Iranian Oil Company* to construct a 240-mile, 8-in. petroleum products line in Iran from Rey, near Tehran, northeast to Sharud. Is laying a pipeline for *Mid-America Pipe Line Company* and announces the following spreads now working: 244 miles of 8 and 10-in. line from a point east of Amarillo, Texas, to the vicinity of Cullison, Kansas; 441 miles of 8 and 10-in. from Cullison to Sheldon, Iowa; 325 miles of 8-in. from Conway, Kansas, to Macon, Missouri; and 318 miles of 6 and 8-in. from Macon to Madison, Wisconsin. Has been awarded a contract by *The Manufacturers Light and Heat Company* to lay 70 miles of 20-in. pipeline from Bethel to Abbottstown, Pennsylvania. Gettysburg is field office site, and Thelmer Davis is superintendent. Has been awarded a contract by *Peace River Oil Company* to construct approximately 37 miles of 8-in. pipeline in Canada. Are sponsors in a joint venture that has a contract with *Alberta Gas Trunk Line Company* for engineering, design, material procurement and construction supervision of approximately 100 miles of natural gas pipelines in various diameters up to 24 in. in Alberta Province. Has been awarded a contract to construct 74 land miles of 12-in. pipeline for *Alaska Pipe Line Company* from the Kenai Unit gas field to Anchorage, Alaska.

● **C. E. Wilson Construction Company, 3718 W. 95th Street, Kansas City 15, Missouri.** Has been awarded a joint contract with D. Michael Curran & Company to construct an 8-in. products system in Montana and North Dakota for *Cenex Pipeline Company*, subsidiary of Farmers Union Central Exchange, Inc.

● **Young and Anderson Company, Box 68, Brea, California.** Has been awarded a contract by *Southern California Gas Company* and *Southern Counties Gas Company* to build approximately 85 miles of 36-in. pipeline from Newberry to Cucamonga, California. Jack Cook and R. R. "Ronnie" Cook have been named project superintendents.

● **H. B. Zachry Company, Box 10188, San Antonio 21, Texas.** Has been awarded a joint contract with O. R. Burden Construction Corporation to construct *Old Ocean Fuel Company's* 370-mile natural gas pipeline between the Gulf Coast area, south of Houston, Texas, to the Fort Worth area.

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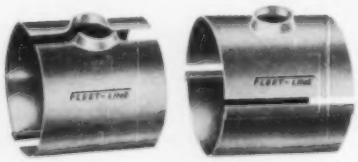

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PIPELINE PERSONALS

Charles R. Younts

Charles R. Younts has retired from Plantation Pipe Line Company after forty-eight years of service in the petroleum industry. Younts, who held managerial positions with marketing affiliates of Standard Oil Company (N.J.) in South Carolina, Virginia, New York, and New Jersey, was appointed to head the products pipeline company in 1940 and served as its first president until 1959 when he was elected chairman of the board. Under his leadership, Plantation has grown from an original maximum capacity throughput of 60,000 bbl per day to today's 332,000-bbl daily capacity. Younts and several of his friends who have retired are joining to form "Retired Associates" to work for nonprofit and charitable institutions at no cost. They will be officed on the 8th floor, 140 Peachtree Street, N.W., Atlanta, Ga.

Martin Kirk Hager, who has spent nearly 30 years in the natural gas business, has been appointed to the gas procurement staff of the Columbia Gas System Service Corporation at Houston, Texas. Hager previously was with Panhandle Eastern Pipeline Company, where he served as assistant to the president, assistant to the vice president for transmission, and vice president for transmission before becoming a director of the company. His other affiliations have been with Michigan Gas Transmission Corporation, Carbide and Carbon Chemicals Corporation, and United Fuel Gas Company, an operating company of the Columbia Gas System.

Promoted to chief engineer at Ohio Fuel Company's Crawford compressor station at Sugar Grove, Ohio, is **Alvin M. Brown.** He replaces **Russell H. Sheets** who has retired. Brown has been in the natural gas business for 45 years, during which he also served as chief engineer at the company's Laurel station.

Kaneb Pipe Line Company has appointed Douglas S. Estes to the post of assistant to the general manager at the company's El Dorado, Kansas, operating headquarters. Estes formerly was associated with Texas City Refining, Inc., as manager of industrial and public relations.

Now in charge of all compressor station operations for Trans-Canada Pipe Lines, Ltd., is **R. P. "Mutt" Hutchison.** Before his promotion to compressor superintendent, he was superintendent of the company's Division One.

Elected to the board of directors of Great Lakes Pipe Line Company is **Karl T. Feldman,** part-interest executive, Sinclair Pipe Line Company. He replaces **James E. Dyer,** vice chairman of the board, Sinclair Oil Corporation.

Joe J. King, senior vice president of Tennessee Gas Transmission Company, has been named a fellow of the American Society of Mechanical Engineers. **H. Lee Norris Jr.** of Relephord & Norris Consulting Engineers and chairman of the South Texas section of ASME, bestowed the society's highest grade of membership on King. King also is a director of Petro-Tex Chemical Corporation and Grand Central Rocket Company, a trustee of the Southwest Research Institute, and a member of the visiting advisory committee for University of Texas' mechanical engineering department.

New vice president in charge of all phases of operations of Texas Eastern Transmission Corporation's 6350-mile natural gas pipeline system is **Ernest T. Robinson, Jr.** He succeeds **E. R. Cunningham** who has retired. Robinson, since joining Texas Eastern in 1947, has served as engineer, assistant pipeline superintendent, division manager, assistant general superintendent and general superintendent of gas operations.

E. T. Robinson, Jr.

Promoted to the newly-created post of gas buyer by Northern Natural Gas Company are **C. James Bulla, James P. Coyle,** and **Richard L. Torczon.** All three men are employed in the gas purchases division of Northern's gas supply department.

Continental Pipe Line Company has promoted N. B. Mavris and J. C. Phelps to vice presidents. Mavris, formerly manager of administrative services and communications, becomes vice president in charge of operations, succeeding **John L. Kelly** who recently transferred to Fort Worth, Texas, as assistant general manager of the company's southwestern region. Phelps, previously manager of new plans and projects, assumes the post of vice president in charge of planning and engineering.

J. C. Phelps

N. B. Mavris

A 20-year veteran in the general construction and pipeline industry in Canada has been anpointed assistant general manager of Marine Pipeline and Dredging, Ltd., He is **E. A. Hooper,** who will be headquartered in Vancouver, British Columbia. President **D'Arcy Baldwin** announced.

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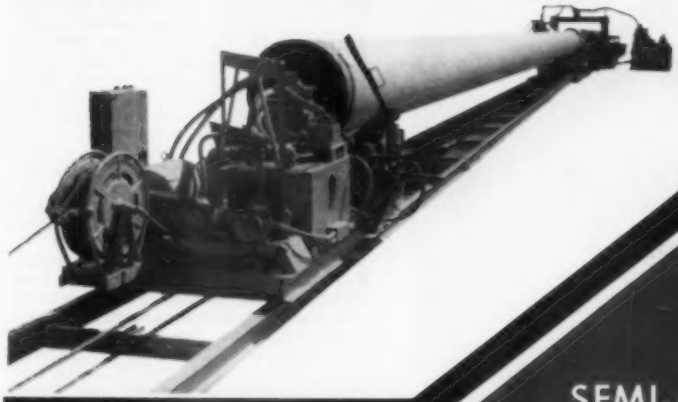

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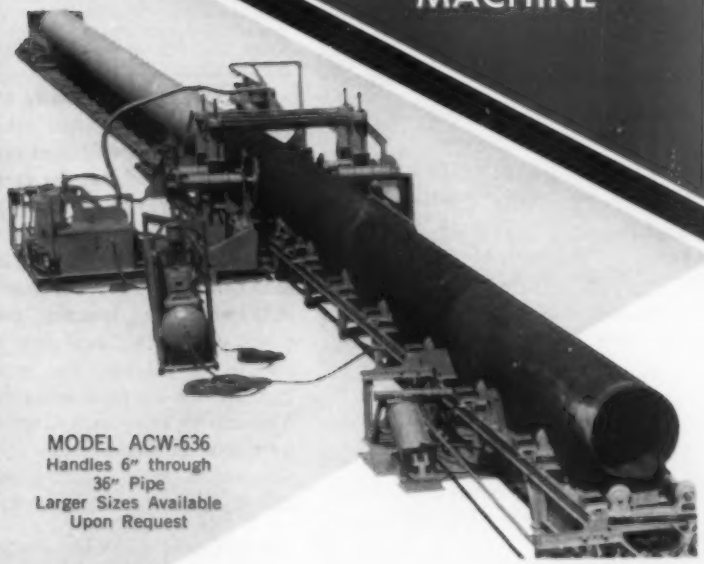

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M. H. Grove

Marvin H. Grove is Walworth Company's new chairman of the executive committee and chief executive officer, a newly-created position. His appointment was announced following a directors' meeting where election to the Walworth board of John W. Collins, an officer of Grove Valve and Regulator Company, also was revealed.

Resignation of California steel executive R. A. Stumm as vice president and board chairman of the Southern Pipe Division of **U. S. Industries, Inc.,** is announced. Stumm founded Southern Pipe and Casing Company at Azusa, California, in 1932, served as its chief executive for 27 years, and board chairman for the past year. D. A. Stromsoe, president of Southern Pipe since 1957, will continue to operate this division.

Elected president of Canadian Allis-Chalmers Ltd. is J. D. Greensward, formerly director of manufacturing, Industries Group, and a vice president of Allis-Chalmers since 1952. He succeeds Harold M. Schudt who has been named director of manufacturing, Allis-Chalmers International.

In other appointments, Allis-Chalmers has named W. C. Henderson manager, utility sales, and A. W. Leighton manager, industrial sales, Los Angeles district.

Newly named sales representatives to district offices of Allis-Chalmers Industries Group are Eugene R. Glazier, Denver, and Harvey L. Stahl, Dallas.

Named manager of Clark Bros. Company's newly created Dallas district office at 4512 North Central Expressway, Dallas, Texas, is William A. Roever. He will be responsible for the sale of Clark engines, compressors, and gas turbines in the central part of Texas and the lower half of New Mexico. The new Dallas district organization also includes: a new sales office in Midland, with Ben Stuart in charge; a new service office in Midland, with Billie Joe Hardin as manager; and expansion of the present Midland warehouse, with P. A. Russo in charge.

Charles M. Beeghly, a steel industry veteran of more than 25 years, has been elected president of **Jones & Laughlin Steel Corporation.** Avery C. Adams, who has served as chairman and president, will continue as chairman and chief executive officer. Beeghly has served as executive vice president since 1958 and as a director of the corporation since 1937.

Another J&L employee for almost 24 years, Thomas M. Hogan, has been appointed new manager of the export sales office succeeding Park B. Turner who is retiring after 22 years of service. Hogan has had extensive experience in J&L's sales and metallurgical departments.

Two new field salesmen have been appointed by Jones & Laughlin Supply Division. J. T. Webster is assigned to J&L's Williston, North Dakota, office. A. B. Edwards is assigned to the Healdton, Oklahoma, store. Both were formerly sales correspondents at Tulsa, Oklahoma.

It's New | Pipeline Equipment

Solid-State Supervisory System

New supervisory equipment that uses transistors, diodes and other solid-state elements in place of relays has been announced for remote telemetering, indicating and control of any function having provision for electrical control. It offers reductions of up to 25 percent in weight and 50 percent in space needs, and is designed to operate on any two-way communication channel including telegraph-grade leased-wire. Control voltage is supplied by a 12-v self-contained battery, but an emergency power loss could be met with a 12-v automobile battery for about 8 hr. Plug-in cards utilizing transistors and diodes direct and receive operation messages to and from remote apparatus through a master station-remote station system. Using GE's proved space-code, the master station sends signals to remote stations in the form of pulses and pauses with operating intelligence carried by the pauses. Each control point has its own code that cannot be mistaken by the equipment for another code. A point on the master station consists of a grouping of indicating lamps and a key to initiate selection. The lamps indicate when the code has been established between the master station and the remote station; when action has been initiated and completed; and an alarm indication for each specific point. Engineered to be functionally compatible with conventional relay-type system, solid-state equipment can be mated as a master unit with existing relay-type remote units, or added as additional remote stations in an all-relay system. *General Electric.*

Circle number (81) on reply card.

Small Regulators Handle Broad Pressure Ranges

A new line of compact, lightweight pressure regulators is designed to handle a broad range of pressures. Pressure reducing models, in sizes from ¼ through ½-in., can be used for inlet pressures as high as 10,000 psi and adjustable controlled pressures up to 6000 psi. Combination pressure reducing and relief regulators are designed for inlet pressures ranging up to 6000 psi and are available in sizes of ¼ through 1-in. Back pressure models will accommodate pressures up to 3000 psi and are available in ¼-in. sizes. "Mity-Mite" regulators — recommended for small and medium flow conditions where high accuracy is needed for non-corrosive service—are of the gas controlled dome type, operating on the principle of balanced pressure with the valve action controlled by a pressure reaction chamber. A restricting orifice connecting the chamber with the dome governs the rate of pressure equalization. *Grove Valve and Regulator Co.*

Circle number (83) on reply card.

Double-Action Gate Valve

A new gate valve that provides a tight seal both up and downstream and requires no lubrication has been introduced in the ASA 400 and 600 lb class and in sizes ranging from 14 through 42 in. for gathering systems and transmission lines. Unusual feature is the design of the floating seats. Soft elastomer for sealing is molded into the back of the heavy ductile iron seat insert ringed with holes. Special tough elastomer is molded on the front or gate side. Pressure forces the soft elastomer through the seat insert holes, reinforcing the tough elastomer and compensating for any wear on the face of the seat. The seats also provide a double action seal. The tough elastomer creates a primary seal against the gate, and as line pressure is increased the gate compresses the elastomer ring until the gate rests against the metal seat. *W-K-M Div., ACF Industries, Inc.*

Circle number (84) on reply card.

A feature of this motor-operated, through-conduit gate valve is that the line fluid cannot penetrate into the interior of the body, whatever the position of the gate may be, the manufacturer states. Any foreign matter carried in the fluid is prevented from settling in the valve due to the continuous wiping contact between the gate in movement and the seat ring. Vereinigte Armaturen-Gesellschaft MBH.

Circle number (82) on reply card.

Spy Detector

QUALITY SERVICE

is there . . . when you need it!

. . . our SPY HOLIDAY DETECTORS are as near as your telephone—in fact, in emergencies our own plane assures immediate service.

Rugged equipment for dependable holiday detection on ¾" to 36" pipe . . . signal—bell, light and spark . . . unaffected by dew or frost.

Call, wire or write.

Pipeline Inspection Co., Inc.

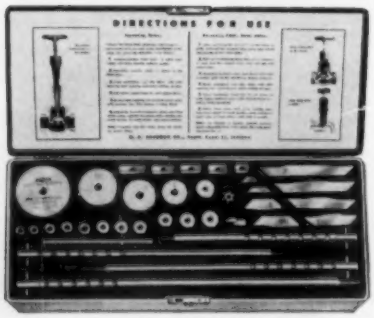
2104 WYANDOTTE STREET • KANSAS CITY, MISSOURI

Day Phone: BAltimore 1-6036

Night Phone: HI 4-6745, EM 1-3824

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

RESEATS VALVES and BIBBS QUICKLY ECONOMICALLY



Easily pays for itself on the first two jobs!

Reseats flat and tapered-seat globe or angle valves —all bibbs and faucets— in place, quickly and accurately. The saving, over tearing out and renewing leaky valves and fixtures, is tremendous.

Cutters operating under screw feed, leave worn, scored seats glass-smooth, level, absolutely accurate and tight.

A guide pilot centers each cutter; a tapered cone centers each spindle. Perfect alignment is inevitable. Cutters guaranteed. Write for literature!

2" for ¼" to 2" valves and ¼" to ¾" bibbs
List price $59.85

3" for ¼" to 3" valves and ¼" to ¾" bibbs
List price $79.50

FREE **catalog showing our pipe repair clamps, saddles, and reseating tools**

M. B. SKINNER CO.
SOUTH BEND 21, INDIANA

For Dry Scrubbing High Pressure Gas

A new dry scrubber that utilizes multiple, small diameter cyclones arranged in parallel to achieve high efficiency removal of troublesome dirt and liquid from gas lines is announced in a complete range of sizes and working pressures to fit any scrubber requirement. The cyclone elements are constructed of an alloy combining abrasion and corrosion resistance with shock resistant qualities needed for reciprocating compressor station requirements.

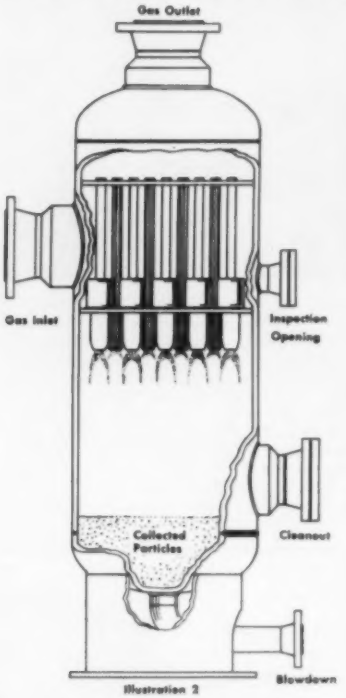


Illustration 2

Compartmented scrubbers to handle the problems of widely varying flows with only one vessel where multiple scrubbers have been required heretofore also are available. *Peerless Mfg. Co.*

Circle number (85) on reply card.

"More Data Per Dollar"

This is the description given the new Honeywell 400 computer. The manufacturer says the computer, capable of handling up to 6000 additions or subtractions per sec, will make electronic data processing practical for many more firms. The basic system includes a central processor, a card reader that handles 650 cards per min, a printer that prints 900 lines per min, and 4 high-speed magnetic tape units. The new system is compatible with the larger Honeywell 800. *Datamatic Div., Minneapolis-Honeywell Regulator Co.*

Circle number (86) on reply card.

New Matched V-Belts

A new and complete line of matched V-belts designed to meet industry needs has been introduced. Three independent matching operations will be performed on these Skinner Crown V-Belts between factory and consumer to assure a match that exceeds standard API specifications by a significant margin, the manufacturer announces. *Skinner Brothers Co.*

Circle number (87) on reply card.

McCORD

Type "C" CHEMICAL

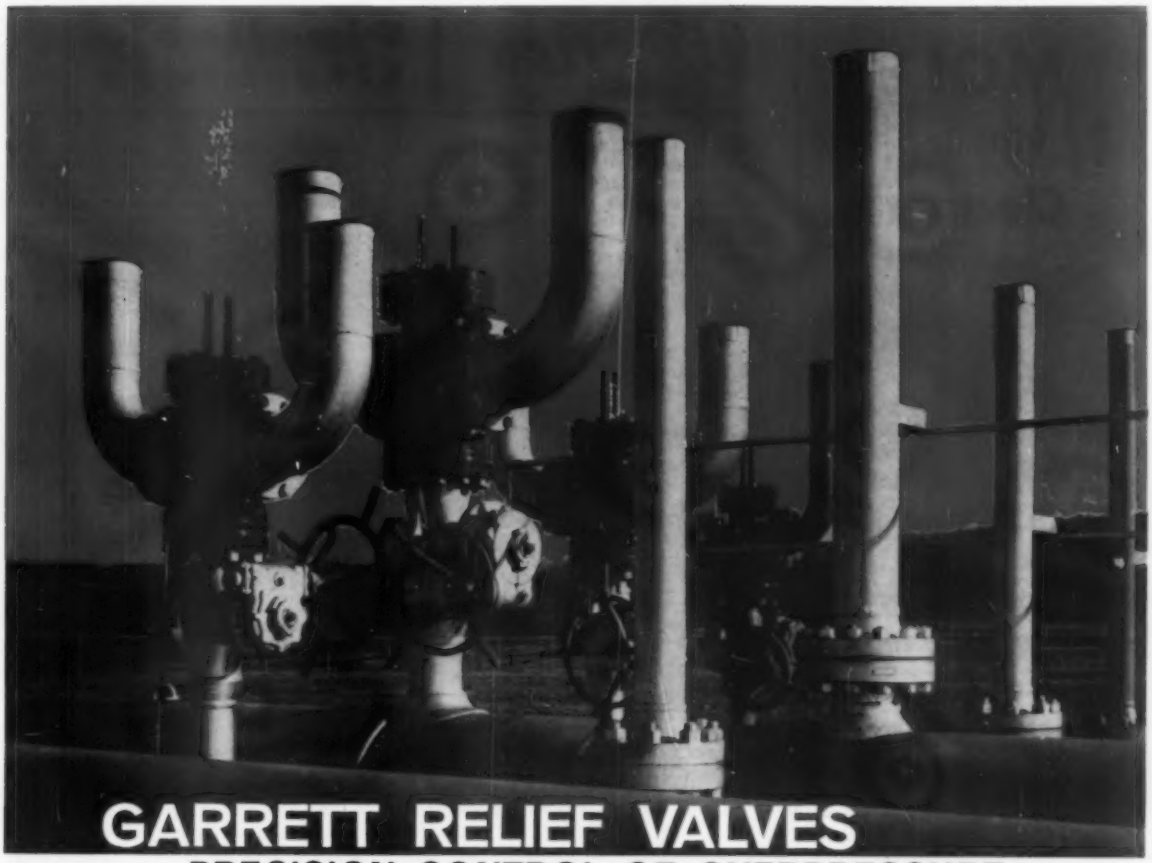
EXTREMELY ACCURATE DEPENDABLE

MEASURING PUMP

Accuracy of delivery in McCord chemical pumps is the result of a finely engineered design with a minimum number of parts. Dependability is insured because working parts are fully enclosed, protected from dirt and the elements. Specify McCord. For sale by National Supply Co.

Lubricator Division

McCORD CORPORATION
Detroit 11, Michigan



GARRETT RELIEF VALVES

PRECISION CONTROL OF OVERPRESSURE

Less than 1 percent of pressure differential will actuate a Garrett Relief Valve. This exactness of control is maintained over hundreds of reset cycles.

When conditions change or the valve is used on other service it can be readily adapted to new set and blowdown pressures. The valve body is not removed from the line to test or reset pressures. Servicing is equally easy and can be done with ordinary hand tools and wrenches without removing the valve from line or vessel.

Automatic blowdown service or safety shutdown can be provided for all Garrett Relief Valves already installed or furnished for new installation.

Garrett field engineers are available to assist in planning your relief valve requirements, write or phone.

USI

Garrett Oil Tools

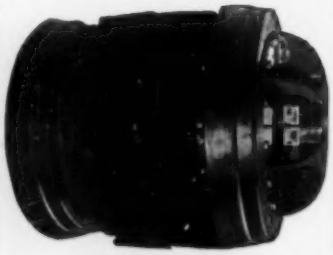
DIVISION OF U. S. INDUSTRIES, INC.

P. O. Box 2427, Longview, Texas

MOLE

Pipeline

Cleaner



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It's New | Pipeline Literature

"Do You Talk 'Computerese'?" asks a new pocket-size dictionary and then proceeds to give you 22 pages of definitions of such terms as binary coded decimal, mnemonic code, binary digit, binary scale, radix, address, drum, gate, bit, and patch (some 82 in all) to make you like an expert on the baffling technical jargon surrounding "electronic brains." *Brown Instruments Div., Minneapolis-Honeywell Regulator Co.*

Circle number (88) on reply card.

Microwave Antenna Manual . . . a handbook of latest information on microwave antennas and equipment, including detailed engineering and installation data on 60 broadband antennas covering all commercial frequency allocations and most of the currently used military bands. Selected cable, waveguides along with accessories and weather protection devices are offered as a complete RF system. *Andrew Corp.*

Circle number (89) on reply card.

Gas Flow Computer . . . a new analog computer that automatically and continuously measures and records the mass flow on an "ElectroniK" recorder . . . is detailed in instrumentation data sheet 7.08. It covers the application of the Honeywell gas flow computer for single and multiple meter runs and also for telemetering systems. *Minneapolis-Honeywell Regulator Co.*

Circle number (90) on reply card.

Pipe Cleaning . . .an 8-page, 2-color bulletin on the use of Wheelabrator airless abrasive blast cleaning for removing mill scale and other surface corrosion. Photographs, drawings, and diagrams explain airless blast cleaning principles, equipment, installations, and five case histories. Information also is included on Wheelabrator steel abrasives used in the process. *Wheelabrator Corp.*

Circle number (91) on reply card.

Detailed Engineering Data . . . that permit approximating horsepower requirements for various applications of "Isotemp" packaged centrifugal air compressors . . . highlight a new 20-page bulletin introducing the line that includes six frame sizes with horsepowers ranging from 1000 to 8000 bhp and capacities from 5000 to 38,000 cu ft per min. The brochure incorporates illustrations and descriptions of all major design features: multi-stage compression; integral intercoolers; unique new water separators; single case design with side connections; integral bearing construction; isolated bearing chambers; back-to-back impellers; horizontally-split case; and drive-thru shaft. *Clark Bros. Co.*

Circle number (92) on reply card.

Multi-Stage Centrifugal Compressors . . . individually engineered to handle air or gas applications and ranging in capacities from less than 1000 cu ft per min to over 150,000 cu ft per min . . . are the subject of a new bulletin highlighted by design and construction features, a keyed cross-sectional view of a horizontally split casing unit, tables showing available shaft seal arrangements, and performance curves. *Allis-Chalmers Mfg. Co.*

Circle number (93) on reply card.

Controls Catalog . . . a new composite catalog illustrating industrial instruments and controls . . . highlighted by a wide selection of liquid and granular solid level controls that include gamma radiation, capacitance, float actuated, electronic, pneumatic, and mechanical. Featured also are the manufacturer's Model B-07 transistorized "Electr-O-Probe" level control and "Mic-O-Float" level switches. *Instruments, Inc.*

Circle number (94) on reply card.

How To Judge Engine Quality . . . a 28-page handbook of special interest to those involved with the purchase of an engine. "Judging Engine Quality" is informative on design, material, workmanship, cost of operation, parts and service, and trade-in or resale value. Cutaway illustrations compare four and two cycle operation; multiple and single orifice injection valves; and precombustion chamber and direct injection of fuels. *Engine Div., Caterpillar Tractor Co.*

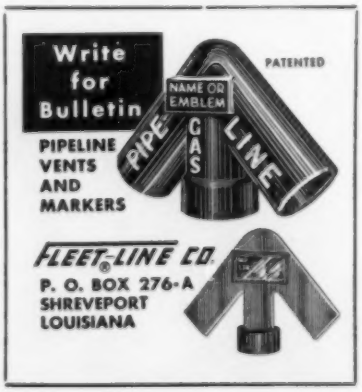
Circle number (95) on reply card.

"Automation and You" . . . a new 16-page, management-oriented publication that discusses the technology, equipment, and economics of automation. It assesses the current state of the automation art; summarizes the need for and economics of automation; provides information for management on six key functions of automation; discusses General Electric products, facilities, and engineering capabilities; and the subject of integrated automation — the so-called "push-button plant" — and how to achieve it. *General Electric Co.*

Circle number (96) on reply card.

Complete Descriptions of all two-way mobile radio base station equipment available from Motorola are contained in a new booklet. Pages are devoted to specifications and photographs of upright cabinets, remote control and desk top consoles, special a-c utility base stations, antennas, monitor receivers, and the "Quik Call" selective signalling system. *Motorola, Inc.*

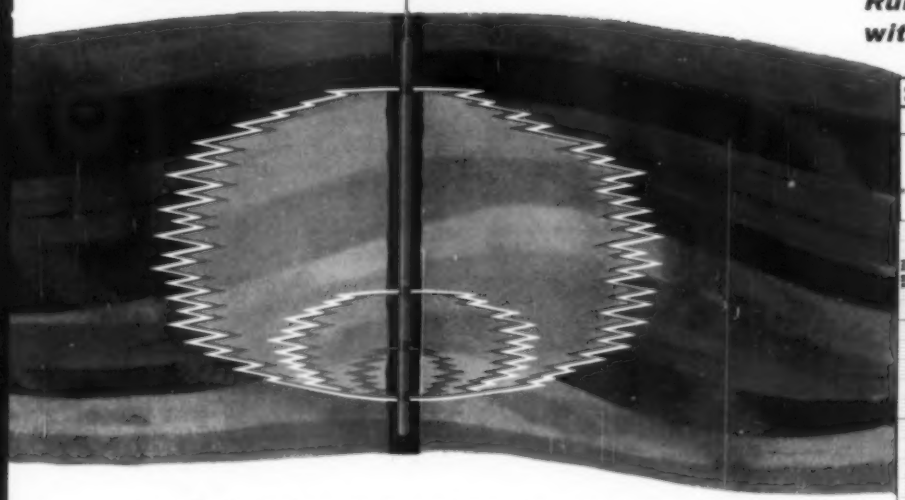
Circle number (97) on reply card.

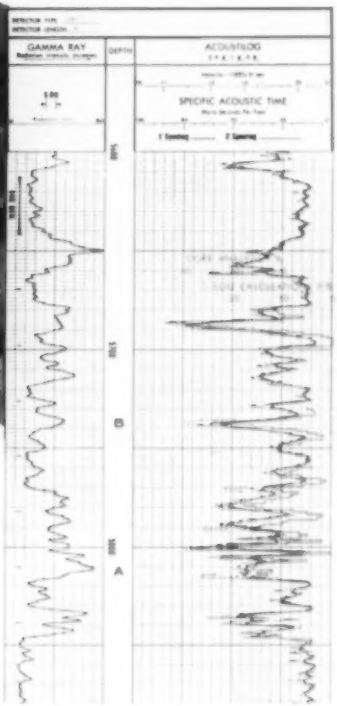


Another FIRST by LANE-WELLS

DUAL SPACED ACOUSTILOG*

Run SIMULTANEOUSLY with Gamma Ray or SP





Lane-Wells Dual Spaced Acoustilog is the most accurate, most meaningful, most informative, quickest run log of this type available anywhere. All new instruments, offered exclusively by Lane-Wells, make it possible to run both 1′ and 3′ spacing curves plus either a self potential or a gamma ray curve all on one trip into the well.

Provides Most Meaningful, Most Accurate FORMATION EVALUATION

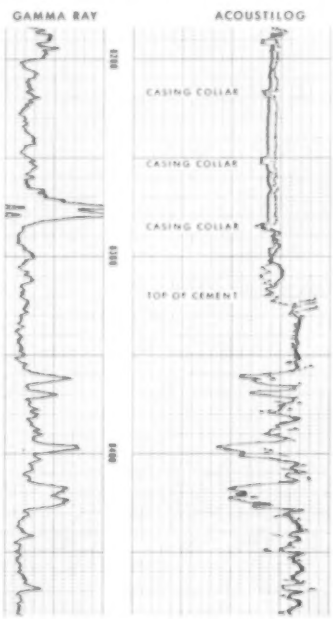
MOST MEANINGFUL!—Because both the 1′ and 3′ curves are recorded while the instrument is in the same position in the borehole, the differences in readings are significant and reliable. Porosities may be read accurately directly from the log. **MOST ACCURATE!** — Exclusive design and circuitry features of Lane-Wells Dual Spaced Acoustilog enable it to measure sound velocities within ±2% of known formation velocities.

PLUS–CEMENT LOCATION

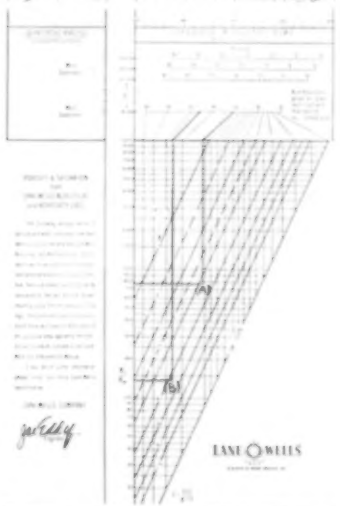
Dual Spaced ACOUSTILOGS have proved remarkably valuable in locating cement and channeling behind casing. Even in areas where other cement locating equipment fails, Acoustilog gets the information.

For complete information about how the all new Dual Spaced Acoustilog can save you money and give you more information about your well, call your nearest Lane-Wells office or write P. O. Box 1407, Houston 1, Texas.

*Lane-Wells Service Mark



Acoustilog used to locate cement.



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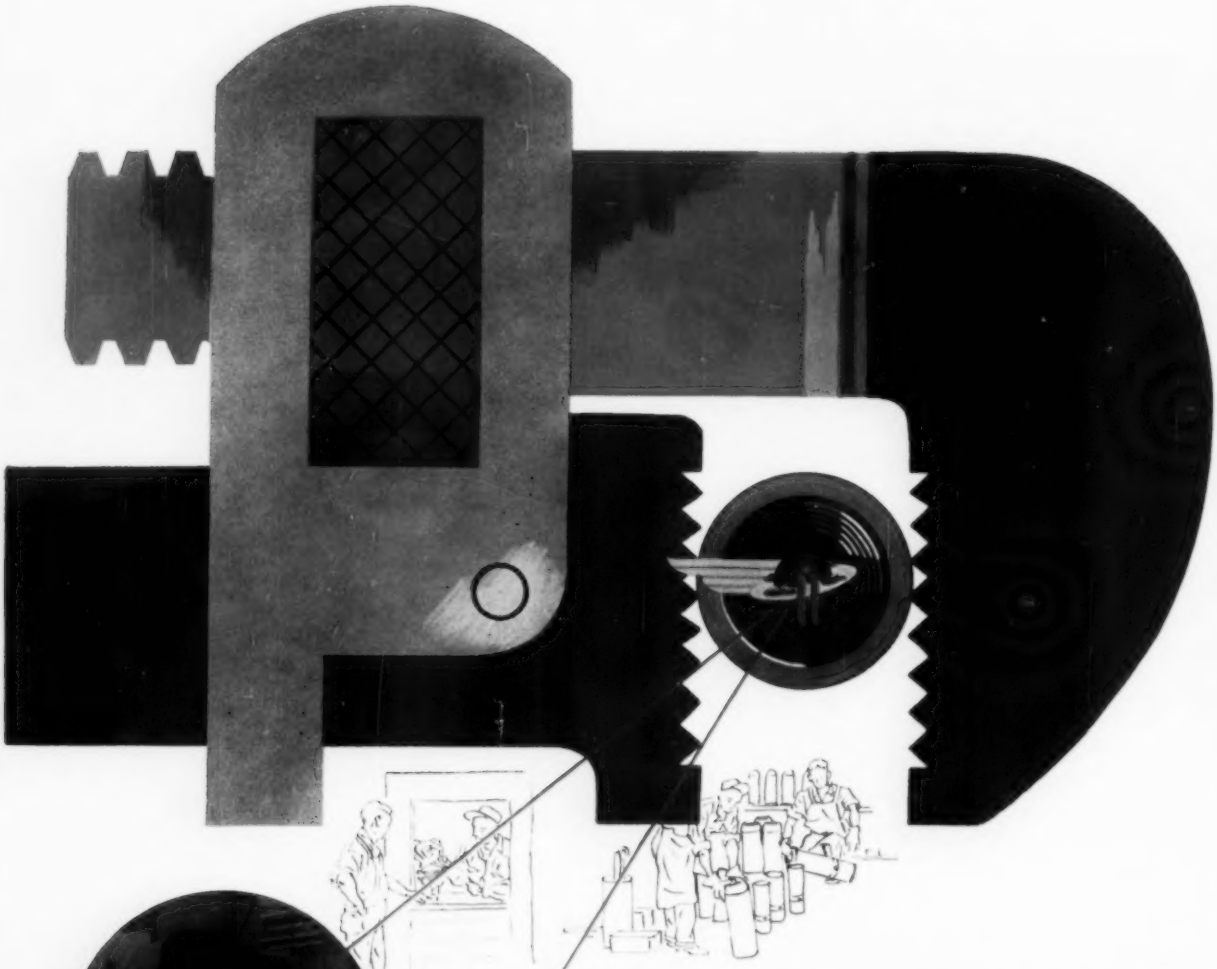

LET'S TALK SHOP

These are the Halliburton men you never see on a cementing job — or fracturing — or testing — or any job taking place at the well site . . . *but none of these jobs could be done without them.*

They are the machinists, foremen, inspectors, helpers, assemblymen in the Halliburton plants and field mechanics on duty in each of Halliburton's 275 Service Centers and Stocking Points dotting the oilfields of the world.

These are the men who apply the master craftsman's touch to every Halliburton tool you use— and, through continuous scheduled field maintenance, help keep "brand new" dependability in every unit of Halliburton's gigantic fleet of trucks, cars, ships and planes.

Dependable equipment can only result from dependable people. We're glad to have them!

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